Monterey Bay Aquarium Research Institute

2008 Ocean Science Summit Report: Climate Change and Ocean Health

Monterey and Moss Landing, California · May 27-29, 2008

Acknowledgments

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Judith T. Kildow

Judith Kildow

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Executive Summary

The Monterey Bay Aquarium Research Institute (MBARI), in collaboration with the American Association for the Advancement of Science (AAAS), The California Council on Science and Technology (CCST) and the U.S. National Marine Sanctuary Program, held the 2008 Ocean Science Summit May 27-29 in Monterey California. A group of engineers, natural and social scientists at MBARI created a unique event and setting to transmit important scientific messages about changes in the oceans to legislators and policy makers, while also giving legislators and policy makers the opportunity to explain their perspectives and information needs to scientists and engineers. Attendees included more than forty of the nation's best marine scientists, more than twenty committee staff members and three elected officials from Washington D.C., and a select group of leaders in the marine community. This event provided unique opportunities for networking, field experiences along the coast and aboard research vessels, and extensive discussions that facilitated a vigorous exchange of ideas, and consensus regarding marine research and policy needs.

The conference participants (a) elevated the visibility and the importance of the oceans in climate change and ocean health, (b) reviewed the current scientific and technological achievements that have helped to reveal key ocean changes and the accompanying issues, and (c) raised the prospect of future opportunities that have high potential for bringing greater understanding about the pressing issues society confronts today.

In conclusion, the Summit was important because connections between ocean science and policy, and scientists and policy makers were made, which will improve communications between the cultures. This report documents event highlights, key ideas, and themes that emerged from the discussions. Additional observations as well as suggestions for follow-up activities are noted.

Introduction

In celebration of the tenth anniversary of the United Nations' Year of the Oceans, the Monterey Bay Aquarium Research Institute (MBARI), along with its partners the American Association for the Advancement of Science, the California Council on Science and Technology, and the National Oceanic and Atmospheric Association's (NOAA) National Marine Sanctuary Program, hosted the 2008 Ocean Science Summit: Climate Change and Ocean Health from May 27 to 30, 2008 in Monterey and Moss Landing, California.

Mike Chrisman, California Resources Secretary, explains innovative governance strategies pioneered in California.

With the goal of elevating the importance of unprecedented changes underway in the oceans, the Summit organizing team brought together one U.S. senator and two members of the House of Representatives and their professional staffs, staff from numerous Senate and House Committees, and an extraordinary community of marine and coastal scientists and leaders. This diverse group sought to highlight the dramatic advances in understanding the ocean environment over the past decade and the rapidly emerging challenges illuminated by new understanding of the following topics: (1) impacts from increased levels of atmospheric carbon dioxide such as climate change and ocean acidification; and (2) land/sea interactions that compromise ecosystems with toxic algal blooms, depleted oxygen zones, and other changes threatening marine life. To focus discussions scientific briefing papers authored by MBARI scientists provided the discussion themes at the Summit.

The titles of these briefing papers are:

- Managing and mitigating risks from ocean changes related to climate change: ocean acidification, increasing sea temperature, and sea level rise.
- Addressing coastal human impacts that exacerbate CO_2-driven changes and threaten human and ocean health from run-off, harmful algal blooms, and other causes.
- Matching ocean technologies with emerging national priorities; new technologies to support science and fuel American competitiveness.

See Appendix A for the complete text of the briefing papers and authors.

In order to achieve the Summit goal—to raise the visibility of ocean issues—more policy-relevant science needs to be communicated about ocean changes to better inform political decisions. The integration of scientific discovery and technological innovation into policy and decision-making has been less than efficient to date. While numerous reasons underlie this problem, a critical step is improving and expanding communication among marine scientists and engineers, legislators, and policy makers. Providing informal and meaningful opportunities for face-to-face dialogue, the Summit was structured to facilitate familiarity with, and better understanding of ocean issues among all attendees.

Primary motivations for this event include:

- Ocean acidification is almost unknown to the public. Yet, its growing presence as a result of greenhouse gas emissions, is a profound issue, poorly understood, challenging to science, and a threat as large as any other to the stability of global habitat.
- The ocean has been absent from climate change discussions, although it covers over seventy percent of the Earth, and is the primary driver of climate processes.
- The science reward system does not encourage scientists to engage in the political process. Policy makers rarely have significant time to delve into the details of science. Personal connections between legislative staff and members of Congress and scientists demystify both cultures and encourage meaningful exchange.
- Emerging scientific evidence and the rate of discoveries as well as the policymaking process are moving faster than information transfers between the two sectors via traditional pathways. Hence, the timely use of science for policymaking is problematic.

Summit Goals

Leading ocean scientists, legislators, and policy makers were brought together to reflect on the decade since the Year of the Ocean to see how far we have come in our understanding of ocean science, technology, and governance, and to

Director of Google Earth and Maps, John Hanke, explains new technologies in marine science, and the capabilities of the new Google Ocean.

discuss how to achieve even greater accomplishments in the next ten years. This gathering was designed to educate and ensure that the latest and most policy-relevant scientific information is used to inform important national decisions at this time of growing environmental challenges and scientific opportunities. It was an over-riding goal of the Summit to promote greater understanding between the cultures of science and policy to enable better information flows though a cross-culture venue for scientists to inform policy makers and for policy makers to inform scientists.

Toward this end, the Summit sought to:

- Identify science and legislative strategies to protect the oceans in coming decades.
- Share growing knowledge about the rapid atmospheric CO_2-driven changes underway in the oceans and land-based impacts on ocean health.
- Explore the uses of cutting-edge technologies that further understanding of complex ocean system dynamics and land-sea interactions.
- Assess mitigation and social adaptation initiatives for atmospheric CO_2-driven ocean changes.

Summit Structure and Process

Nine months prior to the Summit an MBARI organizing team developed a strategy to engage scientists and engineers with policy makers in meaningful discussions about ocean issues. See Appendix B for the Summit overview, Appendix C for the agenda; Appendix D for a list of participants, and Appendix E for the staffing structure. The organizing team provided leadership, organization, day-to-day planning, and implementation for the Summit. Figure 1 diagrams the structure of the Summit.

Sen. Sheldon Whitehouse discusses achievements in ocean governance with other panelists Conrad Lautenbacher, Jonathan Conathan, and Dan Walker.

A planning task force composed of distinguished experts from state and federal government, academia, non-profit organizations, and Monterey-area ocean leaders designated by the organizing team planned the structure and process for this event. The task force identified potential speakers, panelists, and Summit participants; refined goals; and discussed the urgency of creating a better understanding of scientific challenges and new legislation.

Government liaisons for the Summit held two pre-Summit meetings and one post-Summit meeting on Capitol Hill to establish interest, identify prospective participants, lay groundwork for the Summit, and follow-up with Summit participants. They investigated ethics rules to ensure compliance when inviting Capitol Hill members and staff to the Summit.

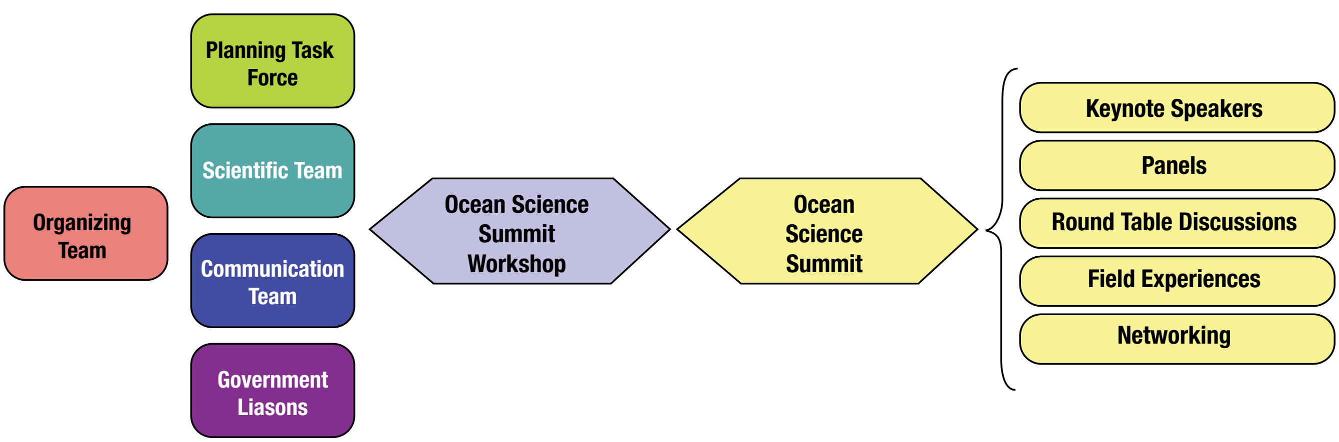


Figure 1: 2008 Ocean Science Summit Process and Structure

An MBARI science committee developed the three climate and ocean health themes for the Summit. This committee took responsibility for drafting three briefing papers, which were later reviewed by the larger group of scientists and engineers who attended the Summit. The edited papers were combined into a single document and sent to all participants in advance, providing necessary background for Summit discussions.

In addition, the science committee (1) identified scientists to participate in the workshop and (2) planned and led the hands-on field experiences.

The organizing team with leadership from the communication team held a pre-Summit communication and political briefing workshop for scientists and engineers. Five experts (communication team) from Stanford and Harvard Universities and COMPASS (see Appendix F) engaged participants in two days of briefings, activities, and discussion of the briefing papers. The majority of scientists and engineers who participated in the Summit attended the pre-Summit workshop.

In addition to the round table discussions, to which everyone contributed, the Summit participants benefited from the ideas of the following invited speakers and panelists.

Keynote Speakers

- Congresswoman Lois Capps
- Michael Chrisman, Secretary, California Resources Agency
- Sylvia Earle, Oceanographer
- John Hanke, Director, Google Earth &Maps
- Peter Seligmann, Founder and CEO, Conservation International

Panels

Achievements in Ocean Governance

- Co-Chair: VADM Conrad Lautenbacher, Under Secretary, U.S. Department of Commerce NOAA
- Co-Chair: Senator Sheldon Whitehouse, Rhode Island
- Michael Conathan, Senate Committee on Commerce, Science, and Transportation
- Daniel Walker, Senior Policy Analyst, Office of Science, Technology & Policy, White House

Achievements in Marine Science and Technology

- Chair: Robert Gagosian, President/CEO, Consortium for Ocean Leadership
- Shirley Pomponi, Executive Director, Harbor Branch Oceanographic Institution, Florida Atlantic University
- James Bellingham, Chief Technologist, MBARI
- Richard Spinrad, Assistant Administrator, NOAA Office of Oceanic and Atmospheric Research

Investing in our Oceans

- Chair: Julie Packard, Executive Director, Monterey Bay Aquarium
- Brian Baird, Assistant Secretary of Ocean & Coastal Policy, California Resources Agency
- Barry Gold, Marine Conservation Lead, Gordon and Betty Moore Foundation
- Julie Morris, Division Director, Oceanographic Sciences, NSF
- Jay Pearlman, IEEE CEO chair and GRSS Advisory Committee member

Frame the Vision for the Future

- Congressman Sam Farr
- Marcia McNutt, President, CEO, MBARI
- Michael Sutton, Vice President, Monterey Bay Aquarium
- Leon Panetta, Director, Panetta Institute

Follow the money! Julie Packard led a panel discussion with other panelists, Jay Pearlman, Barry Gold, Brian Baird and Julie Norris, on investing in our oceans and funding challenges.

Field Experiences

- Land Sea interactions: MLML vessel *R/V John H. Martin*
  - Lead Scientists: Kenneth Coale and John Ryan
  - Captain: Stewart Lamerdin
- Near Shore Issues: Monterey Bay Aquarium vessel *Derek M. Baylis*
  - Lead Scientists: Francisco Chavez and Chris Scholin
  - Captain: Dave Robinson
- Land Sea Interactions: Elkhorn Slough Safari Boat Tour
  - Lead Scientists: Ken Johnson and Mark Silberstein
  - Captain: Yohn Giddion
- Shoreline changes: Land Tour with Professor Gary Griggs
  - Lead Scientist: Gary Griggs
- ROV experiments—Mid-water experiments: MBNMS vessel *R/V Fulmar*
  - Lead Scientists: Jim Barry and Charlie Paull
  - Captain: Lee Bradford
- Deep water ROV dives and Ocean Changes: MBARI vessel *R/V Pt. Lobos*
  - Lead Scientists: Peter Brewer and Peter Walz
  - Captain: Ian Young

Roundtables

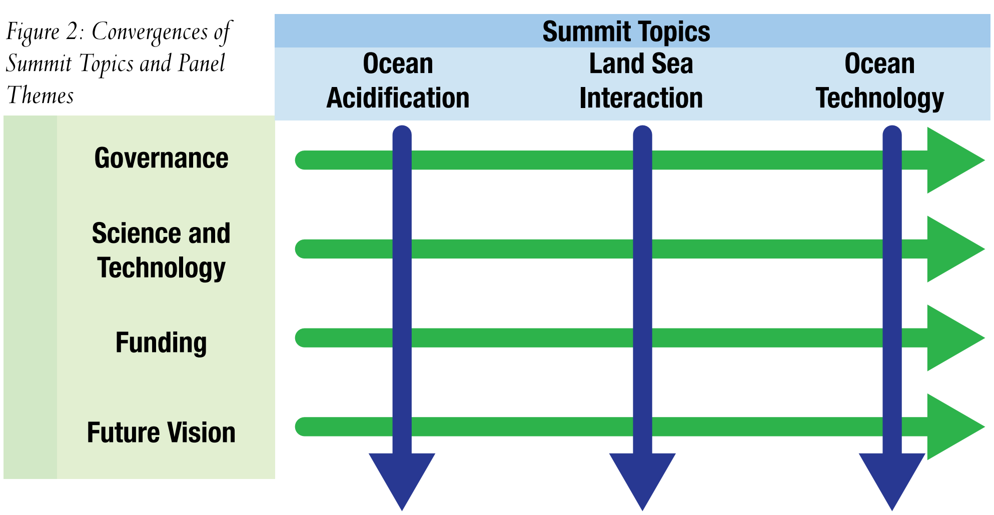
- Lead Moderator: Meg Caldwell
- Chief Scribe: Judith Connor
- Training Consultant: Laura Cantral

Observing the ROV Ventana perform a deep-water dive into the Monterey Submarine Canyon aboard the R/V Point Lobos proved to be a once-in-a-lifetime experience for Adina Abeles, Melé Williams, Jeff Watters, Dahia Sokolov, and Ken Calderia while Peter Brewer explained life in the cold and low-oxygen/high-CO_2 waters.

Key Topics

Each of the three main topics from the briefing papers, elaborated by panelists and keynote speakers, roundtable discussions and field experiences, cut across the areas of governance, science and technology, funding, and vision for the future. For example, the governance panel discussed ocean acidification, land-sea interaction and ocean technol-

Figure 2: Convergences of Summit Topics and Panel Themes



ogy in the context of ocean governance. Figure 2 depicts this relationship.

See Appendix G for each of the six field trip prospectuses.

Summit Discussion Highlights

During the two-day Summit, the main messages from participants that emerged from the range of events and activities were: (1) connections between climate change and ocean health need to be brought to the public's attention now, and (2) protecting the oceans must become a national priority without delay. To support these overarching messages, participants identified the need for: (1) policy makers to better understand the dynamics of greenhouse gas processes that are driving ocean changes; (2) broadened public understanding of ongoing ocean changes; (3) emerging innovative technologies supporting marine science to connect to meet broad national needs; (4) more creative exploration of funding options, especially for long-term experiments and monitoring; (5) encouragement and clarification of policy-relevant science; and (6) institutional change to expedite and facilitate research and understanding. The twelve roundtable discussions were summarized into a PowerPoint presentation (see Appendix H). These messages and needs are categorized below with discussions.

Expanding Scientific Understanding

Marine scientists' current understanding supports the need for oceans to be considered as an integral part of the climate change discussion. The situation is urgent, with increasing rates of change threatening marine life, human life, the economy, social stability, and ecosystem assets and services. Scientists have mounting evidence about ocean acidification, rising ocean temperatures, changes in ocean circulation, resultant shifts in species distribution, sea-level rise that is pinching coastal ecosystems against human developments, and water cycle perturbations that induce major shifts in precipitation and water distribution systems.

While the basic models that scientists use to inform policy are credible, at best the information they can offer is on a coarse scale. Data are insufficient to customize models for effective regional/local decisions. As a result, much policy, out of necessity, is based on untested and un-calibrated models. Scientists participating in the Summit carried the message that it is not possible to predict climate without understanding the physical, chemical, geological, and biological properties and cycles of our oceans, and that even global models of the ocean are only in early stages of development compared to atmospheric models. These points emerged in this discussion area:

Scientists engaged in lively discussion at the aquarium: Dave Scholl (back), Jim Barry, and Richard Feely.

Research Methods Need Strengthening and Expanding

- Increase scientific sampling and enhance monitoring capabilities.
- Refine and expand detection methods and techniques of non-lethal impacts on organisms—before they die.
- Expand and coordinate efforts toward a better understanding of chemistry changes from ocean acidification and more evidence about the rate of pH change and effects on ecosystems in different parts of the ocean.
- Increase research efforts that link land-based activity impacts to ocean acidification and other threats to ocean health, e.g. nitrogen overload.
- Encourage, with caution, research investigations related to carbon sequestration techniques such as iron fertilization and other innovative strategies to combat greenhouse gas impacts until robust and credible evidence indicates they should be put to rest or prudently applied

Research Products Need To Be Developed and Refined

- Global risk/hazard maps with population density overlay (e.g. coastal inundation) in the coastal zone.

- Finer resolution of general circulation models (from large scale to local scales), integrating atmosphere/ocean/ecosystem response.
- Schematics that account for ocean warming earlier and above Intergovernmental Panel on Climate Change (IPCC) projections.

Opportunities Offered by Emerging Technologies

Today observation systems are largely focused on developing a better understanding of ocean processes. These disparate technologies have converged to enable integrated observation systems that allow the study and prediction of ocean processes as a central element of the earth climate system. New technical and engineering approaches have the potential to change the economics of ocean observations, allowing a more pervasive presence in the ocean. Scientists generally agree that present observational capabilities, while impressive, are inadequate to the task of measuring many ocean properties, In addition, resources to replicate existing observational systems do not even exist. The increasing urgency of society's need to understand the ocean and the realities of constrained resources create a fundamental conflict. Much of this is the result of the absence of long-term funding strategies for ocean technology research and development. However, two exceptions stand out that could serve as models for more effective long-term funding and coordination of ocean technologies: the ORION ocean observatory network hosted by the Consortium for Ocean Leadership and projects sponsored by the National Oceanographic Partnership Program (NOPP).

In the future, even more sophisticated systems will apply that improve knowledge to provide forecasts of ocean change, improve management of human impacts on the ocean, and mitigate adverse ocean impacts on society. Below is a list of current and future capabilities that can produce the needed understanding.

Reduce Costs of Underwater Observations

- Robotic platforms are increasingly used to conduct observations and carry out simple tasks without human supervision. Such platforms are dramatically reducing the cost of making underwater observations in the ocean. Underwater robots range from very simple platforms weighing tens of kilograms, capable of making a few simple measurements and transmitting data to shore via satellite, to vehicles weighing hundreds of kilograms capable of making high-resolution maps of the deep seafloor.

Deliver Power and Communication to Remote Areas

- Seafloor cables and sophisticated moorings deliver power and communication to remote instruments in the ocean interior. This enables the creation of remote laboratories on the seafloor, at which scientists can carry out extended observations and perform complex experiments without having to venture to sea.

Raise Quality and Expand Coverage of Ocean Observations

- Improved sensors directly measure chemical and biological ocean properties, eliminating the need to acquire water samples and return them to a laboratory. Not only do sensor developments allow observation of ocean properties in much greater resolution in time and space, but coupled with advances in robotic platforms, they directly enable the creation of pervasive networks for observing global ocean properties.

Use Advanced Capabilities to Detect New Species and their Ocean Systems

- Genomic techniques enable identification of new species in the lab and provide detection in the field. Such advances are revolutionizing scientists' understanding of the role of microbes in ocean processes fundamental to the health of the planetary ecosystem such as the cycling of carbon and nitrogen. The technology

Chris Scholin and Don Anderson focus on the Vision for the Future panelists and learn about America's competiveness.

is in its infancy, yet advancing rapidly, and is opening a new window into a virtually unexplored part of the ocean ecosystem.

Improve Data Management, Exploration, and Access

- Increasingly sophisticated tools for managing, exploring, and accessing data, coupled to the power of the Internet, are transforming how many scientists work. Today, measurements are increasingly made available on the web, in real time. This enables many more scientists to work with the same data, and even to connect different observations to understanding the underlying connections in ocean systems. Ultimately, this increased access to data will foster advances spanning from fundamental understanding to improved prediction systems for natural and man-made hazards.

Promote a More-Coordinated Effort for Technological Innovation

- Tie national priorities for observing and understanding climate change to technology development.
- Extend the IPCC process to develop observational needs to inform scientific and engineering activities.
- Scientists should work with policy makers to promote this new suite of tools under development to push the frontiers of ocean discovery (robotic platforms, seafloor cables, moorings, sensors, and genomic techniques).

Exploring Funding Options

Research, innovation, and communication cannot exist without funding. It is a key ingredient for understanding and managing marine and coastal issues. Funding sources, while limited, should coordinate and optimize opportunities that enable research and monitoring efforts to proceed along with vehicles to communicate findings to the public and policy makers.

Consider Non-Traditional Sources Of Funding

- Establish a long-term public endowment or trust fund to support necessary research and development.

Peter Seligmann and Kenneth Coale exchange thoughts on the roles of NGOs and Conservation International's unusual approach to ocean conservation.

- Promote enhanced collaboration between civilian and military research efforts to optimize human and financial resources to sustain long-term ocean research and engineering needs, particularly as they relate to climate change impacts and other similar issues that have deep national security implications (a la the era of the 1960s and 1970s, when the Office of Naval Research was larger and shared funds with the oceanographic community).
- Encourage public/private partnerships to explore common interests that might leverage greater funding for ocean research and development.

Mobilize Funding for Proactive and Long-Term Research

- Expand funding efforts for research on mitigation and adaptation programs, particularly related to public perceptions of risk that indicate the importance of costs and benefits, e.g., mitigation now vs. adaptation later, or cost of business-as-usual.
- Institutionalize and facilitate long-term research funding, which is not readily available.

Improving Communications

Fundamental differences in culture and perspective, including different interpretations of risk and uncertainty, often divide scientists and policy makers, requiring additional efforts toward effective communications. Scientists and policy makers (defined in this case as legislative members and their staff) carry out their missions (1) in different time-frames (research problems that unfold over decadal periods versus the two-to-six year election cycles), (2) with different expectations (scientific curiosity vs. applied problem solving), (3) are motivated by different incentives (peer review vs. constituency satisfaction) and (4) speak different languages replete with jargon and acronyms that need translating. During the Ocean Science Summit, scientists and policy makers came together and began to identify and address these barriers, and began to remove them. In the case of the scientists the challenge is to keep messages simple.

What Marine Scientists and Engineers Should do

- Use less complex and detailed messages in order to engage and interest public and policy audiences.
- Prioritize and focus their messages to better inform decisions.
- Be clear and unambiguous about what is known and not known about potentially harmful societal impacts from ocean changes so that policy makers understand the state of science and can move forward.
- Identify issues in need of legislation and executive attention.
- Link science to policies and legislation
- Give their best estimates under conditions of uncertainty, because policy decisions will be made regardless.
- Provide consistent consensus messages to policy makers when possible, because conflicting messages from different scientists are not effective in the legislative process.
- Be aware of the differences in the ways policy makers' process information, construct reports and presentations to meet policy needs with societal connections, put conclusions and recommended actions first, and then supporting evidence—a reversal of normal scientific thinking.
- Meet regularly to reach consensus on research strategies and policy-relevant priorities (Joint Subcommittee on Ocean Science and Technology Report[1] provides a possible blueprint for setting priorities).
- More aggressively and uniformly engage in policy discussions related to climate change and technology.
- Coordinate and organize carefully timed scientific briefings on Capitol Hill, with focused messages and comments integral to legislative programs, with leadership coming from one or more organizations.
- Provide concepts and ideas through a formally organized effort to inform legislation.
- Build leadership and a stronger constituency on ocean issues through a concerted and strong collaboration among multiple ocean institutions, e.g. Ocean Leadership Consortium, Joint Ocean Commission Initiative, and others should more aggressively serve this role.

Improving the Policy Process

These are times of unprecedented transition and change, globally, nationally, and locally—environmentally, economically, and politically. The oceans are at the core of many of the environmental and economic changes, and as a consequence will be important to political changes as well. Society faces several crises, or times of major decisions, for both the global economy and the global environment. Each is on a precipice and needs new strategies and directions. Funding availability will undoubtedly be problematic as a

Elkhorn Slough estuary provided the backdrop for the land/sea interactions field experience. Al Teich, Julie Morris, Congresswoman Lois Capps, and Captain Yohn Gideon learned about water monitoring technology and ecosystem-based management.

1 Charting the Course for Ocean Science in the United States, NSTC Joint Subcommittee on Ocean Science and Technology, January 26, 2007.

result of the global economic collapse, yet environmental changes will continue unabated. Not addressing climate change and ocean health will have enormous economic impacts. Society, led by the marine science and engineering community, will need to be resourceful and creative as it presses forward to bring new understanding and evidence of coastal and ocean changes to the forefront of public and governmental concerns and challenges.

Over the past decade some progress was made leveraging funds and talent, by building partnerships among state, regional, and national research programs. The NOAA Integrated Ocean Observing System (IOOS), and its regional Ocean Observing System (OOS) programs, have encouraged observing and monitoring the coastal oceans with more coordination and strategic thinking. However, funding has been woefully inadequate and the nation's marine science and engineering assets have not been optimized as a result.

Because government budget cycles have long lead and lag times, without aggressive intervention at the legislative and executive levels at both state and national levels, marine science will continue to be underfunded and society will be worse off without the knowledge it needs to solve and manage some of the rapidly evolving problems from ocean changes. In an ideal future, new partnerships and new research strategies will be built upon a foundation of clear and practical priorities, which can be implemented to meet short and long-term needs.

What Policy Makers Should do

- Use the best available, peer-reviewed science in legislation and policies
- Ensure that federal programs are adaptable and flexible enough to respond to rapidly changing scientific knowledge.
- Help interpret prospective legislation or charge a responsible person or entity with the responsibility so that scientists can understand the process and perspectives in order to provide effective input.
- Seek coherent government policy direction and provide leadership for the ocean—through a large-scale program approach that includes science, technology, and policy—to bring agencies under a coordinated effort.

During the "Shoreline Changes" field experience Gary Griggs points out a hazard to the participants. Shown are (L to R) Bob Gagosian, Marcia McNutt, Sandra Whitehouse, and Don Anderson.

- Address fragmentation among federal agencies and promote integrated missions on ocean protection early in 2009.
- Mobilize the necessary resources to meet the challenges during the next decade, using multi-sector collaboration
- Integrate oceans into every effort to address climate change, from the national level to the local level.
- Use integrated, ecosystem-based approaches to manage the Coasts, because they are fragile.[2]
- Mobilize funds on the scale of the Manhattan or Apollo projects to address the challenges confronting society from climate and ocean changes, using talent, technology, institutions, and leaders. These projects initiated long-term programs and commitments.
- Create a Senate Ocean Caucus to better inform the Senate on ocean issues comparable to the House Ocean Caucus. This an important step to raise visibility of the oceans. The House Ocean Caucus needs renewed energy and greater visibility to promote ocean stewardship. Consider bicameral meetings of these caucuses.
- Involve the Executive Branch, especially the Office of the President, in ocean issues by establishing a highly visible champion for the oceans through either the Council on Environmental Quality, Office of Science and Technology Policy, or a special climate change or ocean advisor. All levels of government have an important role.

2 Management based on natural system needs as opposed to traditional political jurisdictional considerations.

- Develop enabling climate change legislation for market-based systems, e.g. cap & trade, subsidies for new green technologies, or even carbon emission restrictions such as California's Assembly Bill 32.[3]
- Encourage a larger role for ocean considerations in IPPC deliberations, proportionally more in line with its role as climate-driver and carbon sink.
- Work with staff on Capitol Hill to spur integration and synthesis of science for local action on climate related impacts. Legislation such as the reauthorization of the Coastal Management Act, Oceans 21, and the Ocean Acidification Research legislation are prime examples where scientific and engineering expertise should be aggressively offered and sought.

What Scientists and Policy Makers Should do to Engage the Public

- Aggressively seek public engagement, because constituents are a critical element for legislative action.
- Connect scientific evidence to the public to help people understand how science impacts them (i.e. "so what") and allows them to make informed decisions.
- Convey a sense of urgency about ocean issues to the public.
- Help formulate and then link messages to the public's priorities.
- Employ emerging and accessible technologies, such as Google Ocean, as a communications tool for direct public connections to ocean science issues.
- Create an "ocean dashboard" for the public, such as putting ocean information on the weather page of newspapers and news websites.

Summit Reflections

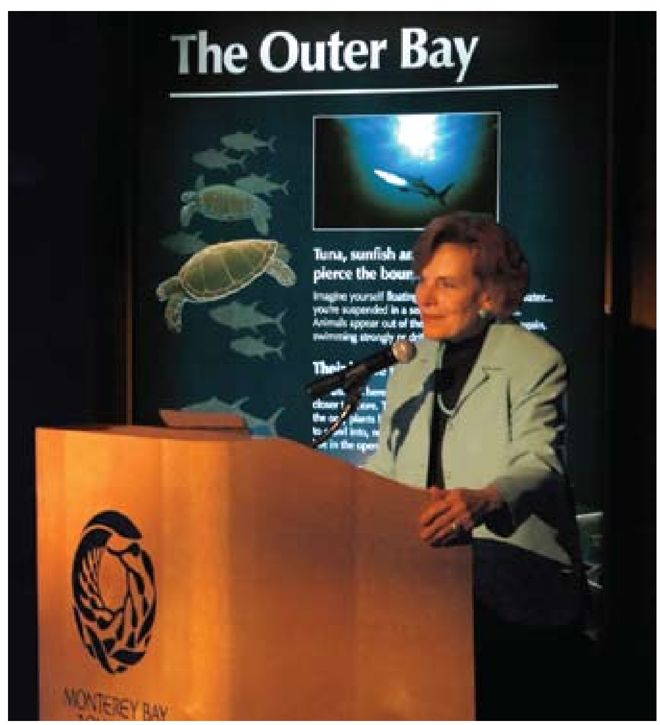
The following accomplishments characterized the success of the Summit.

- Identified the urgency for the broader science community to better synthesize, characterize, and communicate critical ocean health threats and potential solutions to a broad array of decision makers.
- Provided a lively and inspiring environment that promoted the sharing of new ideas that became the foundations for an ongoing dialogue.
- Trained and prepared scientists to be more effective communicators of their research to policy makers.
- Provided a window for legislative staff into "the world of scientists and engineers," and vice versa, and identified gaps between the two worlds.
- Provided a forum and unique opportunity for legislative staff to exchange and stimulate ideas about ocean issues with each other in an unhurried environment.

Though one goal of the Summit was to increase effective communication among marine scientists, legislators, and policy makers, it was the primary goal of the Summit to increase understanding and raise the visibility of the critical state of the oceans and the importance of the oceans in the climate change process. During the Summit there was continued evidence of the value in fostering the two-way conversation between these sectors as both of those goals were carried out.

Some examples of outcomes that emerged during and after the Summit include:

- Scientists reported through a post-Summit survey that they appreciated the extended interaction with policy makers and some noted that they began to understand better the perspective, needs, and the motivation of



"Her Deepness," Sylvia Earle, shared her passion for ocean conservation and the challenges we face.

3 The Global Warming Solutions Act of 2006. This legislation has since been passed and become law.

the public sector. This increased understanding should become valuable as the scientists are called upon to translate their work and give advice effectively to those in the public sector.

- Congressman Sam Farr, from California's 17th Congressional District, attended the Summit, as did several of his staff. Following the Summit he sent the Summit Chair, Judith Kildow, a personal note to thank her for the Summit and to acknowledge the value of the effort. Congressman Farr's office also sent out a constituent update letter soon after the Summit, which linked the importance of the oceans to the issue of climate change. This important link was precisely the outcome sought by the conference planners.
- Senator Barbara Boxer's office subsequently requested information from scientists attending the meeting.
- Legislative staff who attended the Summit noted that the briefing paper, which was distributed prior to the event, was very valuable. Additionally, several suggested that MBARI redistribute the paper on Capitol Hill after the fall recess.
- Numerous legislative staff and scientists indicated in the follow-up survey that they were enthusiastic to participate in follow-up activities after the Summit.

Insights for Future Events

During the planning and implementation of the Summit, the organizing team and its collaborators employed several new methods and approaches. The event format and purpose, itself, was unique in approach, e.g. face-to-face opportunities between legislators and scientists for an extended period of time. Inclusion of field trips with science agendas, and the overall quality of the dialogue that ensued at the Summit, along with the enthusiasm of many who attended to continue the conversations, suggests that more events should occur in the future. We offer some insights that may be useful in planning for future events with similar goals.

More Emphasis on the Science

Future events should give greater emphasis to current scientific knowledge and future opportunities. A select group of MBARI scientists put forth much-valued effort into developing briefing papers by consensus, focusing on what they believed were the most pressing marine science issues. The papers were circulated to all participating scientists in advance for comment and reviewed, revised, and then distributed in advance to the participants. Survey results and follow-up discussions from the participants indicated that the briefing document was valuable. For any event, it is important for all participants to have a common understanding of the particular issues selected for discussion and have the opportunity to delve further into the issues through formal and informal discussions.

The "So What"

The Summit revealed a misunderstanding of who was providing the "so what" aspects of the scientific evidence presented: information that could engage the public. Traditionally, determining the "so what" or link of science to the public's interest has neither been part of the culture of the science nor policy maker communities. Both scientists and policy makers presumed the other was compiling this bridging information. The "so what" piece is crucial to meaningful legislation and programs, and requires attention.

Discussions at the Summit suggested that social scientists had the tools to fill this void and help both natural scientists and policy makers. However, too often, social scientists do not have adequate scientific background to fully grasp the depth and breadth of the scientific information to provide a clear "so what" message. Likewise, the average constituent or legislative staff does not have current scientific information from which to determine the "so what." This problem is identified, and explicated further, in a paper by Susanne Moser for the California State government on translation of scientific information into meaningful public communication.[4]

Working through this "so what" factor with both the scientists and the policy makers at the table could be the focus of follow-up working groups. Another pathway is to follow an iterative process where policy suggestions can be weighed with scientists to anticipate outcomes and through this process or exchange, the policy can be fine-tuned to reflect the best scientific input for a more effective policy outcome.

Ideally, scientific briefing papers for future events would include the "so what," making the scientific evidence policy-relevant. Since this is a critical connection bridging science to policy, any next event should give this topic more attention in discussions.

4 Dr. Susanne Moser Draft CEC PIER-EA Discussion Paper: Building California's Climate-Related Decision Support Capacity and Fostering Social Science Contributions, August 21, 2008

Time Frames

These two communities work in different time frames. Policy makers have quick turnaround times and need questions addressed promptly in days, if not hours. On the other hand, scientists work for months, or years, on a topic and as results become available they gradually release their data in scientific articles, which are carefully honed for journal publication. Often these time requirement differences are frustrating to both cultures when they are working with each other.

Drafting the briefing papers for the Summit involved a core of MBARI scientists at first; then broadened to scientists attending the Summit from across the country for comment and changes. The process took about four months of work to reach consensus by all authors. The scientists clearly indicated they would have appreciated more time. Future events should allow for longer negotiated times for the scientists to prepare any papers.

Upon reflection, it should be noted that the creation of the issue papers did more than provide information for the attendees. The act of creating the papers provided a model of the type of writing that can translate complex issues of science to a format useful for the policy makers. The exercise of writing for the policy audience was a practical example of what it takes to bring a single voice to a complex issue.

However, under normal circumstances, written input to Capitol Hill would have demanded a much shorter turnaround time. Learning to translate complex issues into concise statements written for the policy audience, particularly when multiple disciplines and voices are being combined, is an important element of the process for increasing effective communications between the science and policy communities. Timing and strategy for how to do this effectively need more attention.

Time Constraints

Government ethics rules imposed demanding requirements and time constraints before legislators and their staff could be invited to the event. Additionally, the House and Senate enforce different ethics rules. The agenda had to meet the approval of the ethics reviewers regarding the ratio of work to non-work hours. As a consequence, the agenda was full, including planned activities during most meals. While Summit planners allowed time for informal interaction, some surveys revealed participants would have liked more unstructured interaction. Everyone did agree that the field trips allowed for the most fruitful interactions because of the length of time spent together in a small group. Future events should consider either shorter, or even no presentations at meals, allowing for more networking and informal conversation to build relationships.

Ocean Science Summit Workshop

One of the most unusual components of this Summit was the pre-Summit briefing requirement for the scientists. Summit planners provided a two-day workshop for all participating scientists. This workshop training is described in Appendix F. More than two-thirds of the invited scientists traveled to Monterey a month before the Summit to participate in the pre-event. The workshop was directed by a group of experts carefully selected for this particular event, professionals who had previously offered workshops at MBARI the previous fall.[5] They provided participants with strategies for creating and communicating brief, clear messages to legislators about their research, with lessons in honing content and delivery techniques including body as well as verbal language. Participants received training in both content and delivery, including role playing; and were given a briefing on the legislative process, politics and pending legislation related to the oceans and to climate change, e.g. insights on how Washington worked. Scientists from an all marine science disciplines were briefed on who was coming to the Summit from Washington and some perspective on their jobs and issues they were working on so that the scientists had a better appreciation for their Washington counterparts at the Summit. From the interactions at the Summit itself, the investment in the workshop appeared to have prepared the scientists for effective interaction. During all sessions of the Summit scientists appeared comfortable in discussions with policy makers, having used what they had learned in the workshop. The interactions were thoughtful and effective, and it was noted that the scientists easily engaged the policy participants.

Translating Science to Policy

A premise of the Summit was that direct communication between policy makers and scientists was desirable, because those doing the research know it best and express the most passion. Efforts to enable this effective communication were at the core of the Summit preparation and execution. It was acknowledged throughout the planning,

5 Experts from Harvard and Stanford Universities and COMPASS

Meg Caldwell summing up two days of round table discussions: We govern by crisis, we face a crisis, and the public sees no crisis.

and during the writing of this report, that communicating science to policy makers is most often done by intermediaries: people who help translate the language of science to policy and vice versa and who identify the "so what" factor that relates science to society. Using the tools of training and other components to reduce or eliminate the need or dependence upon these intermediaries or translators was extremely important.

After the Summit and during the process of writing this report the planners revisited this goal numerous times. It became apparent to the authors of this report that the role of the intermediary translator is still important and is not likely to be completely supplanted by scientists who undertake direct interactions. The culture of science is well established as is the culture and style of the policy maker. Though there will be scientists who are effective and enjoy this intermediary role, most scientists cannot be expected to engage without the urging and assistance of translational people or organizations. What mechanism organizes these interactions is a topic that merits more discussion to ensure sufficient, effective, and timely translation of science into the policy arena.

Sustaining the Momentum

During the Summit there was discussion of next steps that included the possibility of working groups and/or briefings in Washington. Efforts should be made to continue conversations among those who attended the events and to provide follow-up opportunities. In the case of the Summit, there was a survey distributed soon after the Summit to get feedback. There was also a follow-up meeting several months later between several members of the organizing committee and many of the legislative staff who attended the Summit to keep the conversation going and to get additional ideas about how to do that.

Field Excursions and Hands-on Experience had Value

It is evident from the surveys and follow-up interaction that the field excursions provided some of the most, if not the most, valuable experiences of the Summit. Participants noted that they found the science discussed on their excursions very valuable. Of particular value, the participants said, was the opportunity to network and build relationships between the scientists and the policy participants. We expected the field excursions to be valuable, but it appears they exceeded all expectations.

Location and Timing

The location and time of the Summit affected the number of elected officials (and staff) who were available and/or interested in attending. The planners expected some difficultly drawing many elected officials and their staff to the west coast during a short recess in an election year. The responses were surprisingly positive given those challenges. Shortly before the event, with 35 Congressional participants confirmed, several members of the Appropriations Committees in both the House and Senate were forced to decline given the demands of the legislative calendar (appropriations and climate change bills in particular). Fortunately, many valuable staff, one Senator, and two Representatives participated in the Summit. For future events, reviewing legislative and political calendars for timing and considering east coast locations to shorten travel times are important. Planning for unavoidable last-minute cancellations due to legislative demands is prudent.

Roundtable Organization

Among the most valuable segments of the Summit were the roundtable discussions, which provided moderated interactions between the scientists and the policy makers. Discussion groups are difficult to moderate and direct toward specific outputs. In the case of this Ocean Science Summit, the discussions were designed to focus on the science, but the communication strategies dominated the conversations. A long-term investment to ensure and clarify focus and structure would be worthwhile for future events in order to achieve the goals set forth in the agenda and to reach defined outcomes. These can be the most productive elements of discussion if carefully planned, but much time needs to be given to making them successful.

Next Steps

It became apparent during the planning and execution of this event that there is not the strong leadership or consensus of voice in the marine sciences that one would find in other disciplines. Atmospheric scientists, for example, have traditionally spoken with a single voice and had success in pursuing their agenda. The steps below are an effort to lay out components of a strategy that could help consolidate the disparate interests in the marine community with the goal of bringing critical issues to the forefront for this country and the world to address.

1. Adopt a large-scale organizational initiative on ocean/climate change.
2. Stimulate the formation of a joint House-Senate ocean caucus.
3. Establish a working group to identify priorities and target markets with clear messages about oceans and climate change.
4. Make the Ocean Science Summit an annual or biennial event.
5. Hold regular ocean-focused briefings on Capitol Hill on key issues.
6. Issue regular production of ocean-related briefing papers generated by marine scientists and groomed for policy makers.
7. Make communications training for marine scientists and social scientists widely available.
8. Organize and implement a scientific consensus statement on marine scientific priorities for understanding impacts of climate change on ocean health.

All of the above recommendations require leadership from some organization(s) to bring them to fruition. The first step toward fulfilling this short, but important, list is to get commitments from appropriate groups to take on these responsibilities. These are important tasks that we encourage the ocean community to undertake.

Appendix A: Briefing Papers for Summit Participants

Ocean Science Summit: We are Changing the Oceans and the Oceans are Talking Back

The oceans are an important driver of planetary systems—including our climate. They also provide enormous value to the U.S. economy, and to our social well being. Coastal counties alone account for 50% of the U.S. Gross Domestic Product, jobs, wages, and population; this, on little more than 7% of the nation's land. Oceans are arguably the nation's most valuable resource (NOEP, 2006).

The importance of ocean health to societal well-being has become clear after decades of research and study by dedicated scientists. Never before have they observed such rapid and uncertain changes in all parts of our global oceans. It is imperative that we understand the source and nature of these changes, and their implications for society. Through this understanding we can work towards managing and addressing the sources of the change that negatively impact humans.

It is now clear that humans have had a large part in creating this fast-changing and unpredictable world (IPCC, 2007). Our activities are changing the oceans in ways that jeopardize sustainable development, the health and well being of our citizens, and the capacity of marine ecosystems to support products and services valued by society. Ocean scientists who have been observing these changes first hand want to share their knowledge. They feel an urgent need to work with legislators, other members of the policy community, and the public to ensure that the evidence from their research is incorporated into public policy, and that science relevant policies strengthen their ability to provide the policy-relevant information.

Major climate events, shifts in natural planetary systems, and chemical and geophysical changes with resultant biological and ecological changes are evidence of changing atmospheric and oceanic systems. Signals of change can often be subtle, and can only be picked up by innovative observation devices.

Emerging technologies and computing power can provide us with the capability to complete rapid assessments and timely predictions needed to manage and adapt to these changes in ways that will (1) help to ensure the safety and security of citizens now and into the future; (2) improve our ability to protect our environment for generations to come; and (3) unlock the economic and health benefits of ocean resources.

The following three briefing papers provide a glimpse into three major areas of research that will be highlighted at the Ocean Science Summit, chosen because we believe they can inform decisions today and in the years ahead. These are not the only pressing issues, but they form a foundation for addressing major concerns.

1) The oceans and climate change impacts – unprecedented changes as a result of increased CO_2 in the atmosphere,
2) The land/sea interface and the health of the oceans – provides insight into emerging concerns such as harmful algal blooms, and
3) Emerging technologies that will provide the tools to better understand the unprecedented changes underway in our oceans and serve our nation's priorities.

Spearheaded by scientists and engineers from the Monterey Bay Aquarium Research Institute, the briefs are the product of a collaboration of scientists who attended the Summit. They provided the necessary background for the discussions that took place during the Summit.

Managing Risk from Impacts of Climate Change and Ocean Acidification on the Ocean[1]

Introduction

Large-scale climate change, driven by the accumulation of greenhouse gases in the atmosphere, is well underway. In order to stabilize the climate, large and permanent reduc-

1 Lead Scientists: Peter Brewer and James Barry

tions in gas emissions must be achieved globally—a difficult task in a world with growing populations.

Climate stabilization requires an understanding of the oceans' significant role in climate change. The world's oceans provide the largest sink for excess heat and CO_2, but its capacity to store the excess is not unlimited. Ultimately the oceans' continued capacity to absorb excess heat and CO_2 will determine the rate of atmospheric emissions that are possible while still achieving a stable climate. The following factors are known in broad terms and are directly measurable today:

- ~530 billion tons of fossil fuel CO_2 emissions are directly observable in the oceans (Sabine et al., 2004), increasing the acidity of surface waters by 25%, with negative consequences for marine life.
- Most of the heat trapped by greenhouse gas emissions is absorbed by the oceans, with little remaining over the long term in the atmosphere—thus, the heat from climate warming is stored mainly in the oceans.
- Direct observations of climate change that scientists have documented and measured include the warming of the ocean and the accelerated melting of glaciers and sea ice (Bindoff et al., 2007).
- Ocean warming observed today was caused mainly by greenhouse gases emitted 30 years ago. This long lag in the atmosphere-ocean system means that the warming potential of the past thirty years of CO_2 emissions (55% of all fossil fuel emissions) have not yet been realized.
- Oceanic uptake of heat and CO_2, occurring on time scales of 10s to 100s of years, is the primary buffer against rapid atmospheric changes. Acidification of the ocean caused by an increase in CO_2 levels is typically counteracted by the weathering of rock. But because this weathering process requires 100s of 1000s of years, rapid increases in atmospheric CO_2 leads to the acidification of ocean waters (Knoll et al., 2007).
- The long-term effects of present-day carbon dioxide emissions on ocean ecosystems are not well understood, but troubling, unanticipated consequences for marine systems such as calcifying organisms (e.g. coral reefs) and deep-ocean ecosystems are beginning to emerge (Hoegh-Guldbert et al., 2007).

Ocean Acidification

Ocean acidification, a product of rising oceanic CO_2 levels, has not received the attention that a problem of this scale and magnitude merits. The Intergovernmental Panel on Climate Change (IPCC) series of reports set standards for the science of physical climate change, but has paid far less attention to the chemical and biological consequences of rising CO_2 levels in the ocean. The issues are troubling.

- The oceans have now absorbed some 530 billion tons of atmospheric CO_2.
- Today CO_2 enters the world ocean at a rate of ~1 million tons per hour.
- Ocean pH has already lowered and will continue to decline at least 0.3 pH units by mid-century causing a loss of some 38% of the dissolved carbonate ion required for the formation of shells of many marine animals (Brewer, 1997).
- Marine animals find it measurably harder to survive when they are exposed to less oxygen and more CO_2 (Pörtner et al., 2005).
- Comparable changes have not been experienced on Earth for tens of millions of years, and will have negative impacts on almost all marine life.
- Ultimately, some 85% of all CO_2 emissions will be transferred to the ocean — but as more CO_2 is absorbed by the ocean, its capacity for additional storage diminishes, thereby reducing the rate of CO_2 uptake. Climate stabilization at a doubling of the pre-industrial CO_2 level (560 ppm) implies storage of some 6.2 trillion tons of CO_2 in the ocean at equilibrium.

Ocean scientists are concerned that a wide variety of organisms with calcium carbonate shells, such as reef-building corals, sea urchins, shellfish, crabs, and even some key microscopic planktonic species, are at risk due to the changes in ocean chemistry (Orr et al., 2005). Coral reefs will face dual threats due to bleaching from rising temperatures and carbonate stress from lower pH (Hoegh-Guldbert et al., 2007). Particularly concerning is the evidence from the geologic record showing massive loss of coral reef building species during periods of rapid increases in CO_2 levels, for example, at the Permian-Triassic boundary 255 million years ago (Knoll et al., 2007).

Recent research has shown that ocean warming, acidification, and reduced oxygen levels, all linked to greenhouse gas emissions, can increase stress levels for ocean life. For instance, these factors can have negative impacts on the reproductive capacity of shrimp, growth rates of marine fishes, and survival of deep-sea animals (Ishimatsu et al., 2004; Barry et al., 2004; Ichimatsu, 2005). Regions only a few hundred meters below the surface where oxygen levels are already naturally low and only marginal for supporting higher life forms, are changing – these 'oxygen minimum zones' are now known to be intensifying and expanding greatly in depth and latitude (Stramma et al., 2008).

Technologies and research developed by ocean geochemists have been able to uncover the changing chemical signals of the world's oceans, yet predicting the long-term ecosystem impacts of these changes is far more complex and is an area of active research. Changes highlighted here are important to keep in mind when devising schemes to mitigate the negative consequences of global warming. Those who fail to address the CO_2 problem, such as the injection of particles into the stratosphere to reflect some fraction of the sun's incoming radiation, only addresses one aspect of the climate problem, and perhaps not even its most threatening aspect (Matthews and Caldeira, 2007).

Changing Temperature and Climate

CO_2 levels in the atmosphere are increasing much faster than anticipated, and our society's ability to stem this growth is still too limited to generate the changes required for climate stabilization. It is prudent, therefore, to plan for warming sooner and at or above the high end of recent IPCC projections.

For the ocean and coastal states this can result in:

- Higher sea levels from thermal expansion and melting land ice.
- The effects of changing climate on agriculture and fisheries.
- Changes in marine fisheries with a marked northward shift of warm water species (Barry et al., 1995; Ishimatsu et al., 2005).
- Reduced tolerance to environmental change due to synergistic effects of warming waters, lower oxygen levels, increasing CO_2 levels and decreasing pH (Pörtner et al., 2005).
- Changes in ocean physical forcing and seasonal cycles in the fundamental productivity of the ocean. This can affect when prey is available for young fish, seabirds and mammals, ultimately affecting their reproductive success.
- Preparation for adaptation and revision of fisheries management policies as marine populations respond to changes in climate and other stressors.

The Land-Sea Interface[2]

Introduction

Actions near the coast and in the interior of the nation are driving strong and negative impacts on the coastal ocean.

- Rising sea level driven by global warming threatens coastal habitats and our economic and domestic infrastructure. The warming associated with CO_2 emissions is expected to raise sea levels a half meter or more during this century. This prediction is considered conservative as it does not account for additional sea rise due to accelerating losses of sea and glacial ice (Laws, 2008; Hansen, 2007).
- Globally, 100 million people live within 1 meter of sea level, including nearly 3 million Americans in the southeastern United States (Rowley et al., 2007; Sandifer et al., 2007). As demonstrated by Hurricane Katrina, losses of tidal wetlands exacerbate damages due to coastal storm effects that penetrate further inland.
- Nearly 120 million Americans now live in the coastal zone. When combined with an aging infrastructure, this trend leads to frequent bacterial contamination of the coastal waters and directly impacts human health with economic losses estimated in the billions of dollars (Santo Domingo and Hansel, 2008; Given et al., 2006).
- Habitat loss and degradation of rivers and estuaries that serve as nurseries for fish and shellfish have contributed to the collapse of our fisheries. Nearly 55% of the federally managed fish stocks are overfished or fully exploited, and 31 species may be at risk of extinction. Many stocks of salmon and 74 species of marine mammals are listed as threatened or endangered under the U.S. Endangered Species Act. Despite more aggressive management in recent years, fishing pressures during the past century

2 Lead Scientists: Chris Scholin, Ken Johnson, and John Ryan

may have forced adaptive changes in natural fish stocks that reduce their ability to rebound.

- Human production of fixed nitrogen compounds, primarily for fertilizers has eclipsed natural production rates. Increasing fertilizer concentration in rivers flowing from the interior of the nation drive expanding oxygen deficient zones and more frequent harmful algal blooms in the coastal zone (EPA, 2007; NRC, 2000; Ramsdell et al., 2005; Anderson et al. 2002).

Changes in the ocean also impact the land by altering weather patterns, which can result in more frequent droughts in some areas and devastating storms in others. These changes increase the susceptibility of coastal areas to coastal inundation, erosion [and fire risk].

Mitigate the Impacts by Integrating Regulation, Management, and Science

A degrading environment reduces the capacity of coastal ecosystems to react to threats and to adjust to new conditions. Fragmented management of degraded systems produces ineffective responses and, frequently, creates unexpected and negative results in a fragile environment.

- Diversion of Klamath River water for agriculture in 2002 resulted in the collapse of that river's salmon fishery, with economic repercussions along the U.S. Pacific Coast. Dramatic impacts of seemingly modest management decisions occurred because previous environmental changes (e.g., dams, logging, habitat modification) had reduced the capacity of salmon populations to respond to any additional threats.
- Oxygen deficient zones in the northern Gulf of Mexico are fueled by fertilizers carried in the Mississippi River (Turner et al., 2007; Rabalais et al., 2002). Corn-based ethanol production in the Mid-West used to reduce our fossil fuel dependence has led to increased fertilizer run off. The economic incentives to maximize corn production appear to have reversed previous successful efforts to reduce Mississippi River fertilizer loading (EPA, 2007; Donner and Kucharik, 2008). The oxygen deficient zone in the Gulf of Mexico now spans an area larger than the state of New Jersey and the area will grow. In addition, these fertilizer inputs increase the frequency and extent of harmful algal blooms (Anderson et. al. 2002, Ramdell et al., 2005; NRC, 2000). Toxic algal compounds impact human health, commercial and sport fisheries, and often result in catastrophic losses of wildlife.

Both the U.S. Commission on Ocean Policy and the Pew Ocean Commission Reports call for more integrated ecosystem-based approaches to address management of the coasts.

Improved Data Required

In many cases, we simply do not have the data and information required for more effective management of coastal areas. As a result, unanticipated impacts in a changing environmental are not observed until too late.

- Is it safe to swim? Can we eat the shellfish? Ever more frequently, the answer is no. Current methods for assessing bacterial loads and harmful algal blooms involve long lag times (days) between sample collection, transport, laboratory analysis and reporting. By the time a threat is identified and a beach is closed, natural processes may have removed the bacteria. Beaches often remain open when they should be closed and closed after the threat has dissipated.
- Moderate storms cause significant damage and the changing climate makes extreme events more likely. Infrastructure designed to withstand 100-year events will be tested ever more frequently. As learned in Hurricane Katrina, sensor and information systems that identify local threats, such as levy breaches and flooding, and allow civil authorities to react in real time are essential.

Managing the coastal ocean is like running a large corporation with infrequent and incomplete accounting: a recipe for bankruptcy. Improved and integrated coastal management depends on sustained and efficient ocean monitoring and accurate predictions of changes and threats.

Summary

Coastal systems are experiencing unprecedented rates of change that render these systems more susceptible to future natural hazards, make them more costly to inhabit, and leave them less able to support living resources (Sandifer et al., 2007; Ramsdell et al., 2005). The social and economic costs of uninformed decisions are increased accordingly.

- An integrated approach to coastal regulation and management that spans multiple jurisdictions is necessary to sustain and restore ecosystems.
- More complete and timely flow of information from sensors embedded in the environment is an essential component of integrated coastal management.

Ocean Technology – Foundation for Revolution

Introduction

The ocean covers more than 70% of the planet and contains an ecosystem that produces half the oxygen that enters the atmosphere each year (Field et al., 1998). Changes in distant and remote portions of the world ocean, such as growing dead zones in the ocean interior (Dodds, 2006), harmful algal blooms along our coasts (Fleming et al., 1999), and diminishing sea ice in the Arctic (North, 1984), impact the nation's economy and the health and well being of our citizens. However, the hazards and costs of working in the ocean environment have made the ocean interior poorly observed and therefore challenging to understand. Fortunately, new technologies and knowledge have brought us to the brink of a revolution in our ability to detect and predict changes in the ocean.

Investments in remote sensing systems such as Earth observing satellites, and seagoing science have provided insights to the complex and interconnected nature of the ocean. However these still only provide occasional glimpses into the ocean interior. Today, ocean researchers are developing a new suite of tools which lay the foundation for a pervasive presence throughout the ocean. These advances include:

- Robotic platforms conduct observations and simple tasks without human supervision.
- Seafloor cables and sophisticated moorings deliver power and communication to remote instruments in the ocean interior.
- Improved sensors directly measure chemical and biological ocean properties.
- Genomic techniques identify species in the lab and provide detection in the field.
- Tools for managing, exploring, and accessing data allow sophisticated analysis of observations and enable the development of predictive systems.

These disparate technologies have converged to enable integrated observation systems to study and predict the ocean as a central element of the Earth climate system. For example, ocean-atmosphere interactions observed by mooring arrays in the central Pacific allow predictions of processes in distant parts of the world, such as productivity of fisheries off Peru (Barber and Chavez, 1983) and average rainfall over the southwestern United States (Sheppard et al., 2002). Today these observation systems are largely focused on developing a better understanding of ocean processes. In the future, even more sophisticated systems will apply that improved knowledge to provide forecasts of ocean change, improve management of human impacts on the ocean, and mitigate adverse ocean impacts on society.

Rapid Advances Provide New Capabilities to Observe and Predict the Ocean

One of the great challenges of the 21st century is to create the capability to predict the ocean and its ecosystem. Much like the genome project or going to the moon—the goal is in sight, but the technology must advance, through creativity and innovation, to allow us to get there. We are not starting from scratch; there are many building blocks in place.

Robotic Platforms: Because humans can venture to the extreme depths of the ocean only at great cost, researchers are creating underwater robots to serve as our surrogates in this hostile environment (Bellingham and Rajan, 2007). Robots range from very simple devices that drift with ocean currents reporting their measurements by satellite, to extremely sophisticated robots carrying out "intelligent" missions without human supervision, such as making high-resolution maps of the seafloor. Applications range from mapping the large scale currents within the ocean to measuring the thickness of sea ice in the Arctic. As the reliability and capabilities of undersea robots improves, scientists are able to carry out new and more complicated tasks.

New Sensors: While sensors for measuring many physical properties of the ocean, such as temperature and salinity, have been mature for years, the availability of sensors for characterizing ocean chemistry and biology are in their infancy (Johnson et al., 2007). Sensors are essential for understanding the key biological cycles of our planet – the carbon and nitrogen cycles – both of which have been greatly changed by human industrial and farming practices, and both of which are changing the ocean in ways we cannot predict. Technical progress is rapid, and *in situ* measurements now allow direct sampling of ocean properties such as dissolved CO_2 and pH, and biological drivers like nutrients and light.

Genomics: The chemistry of the ocean is largely shaped by the thousands of micro-organisms living in every drop of seawater. Advances in genomics have provided scientists with a new window into the lives of the tiniest ocean creatures, allowing identification of some of the smallest yet most numerous inhabitants of the planet (DeLong and Karl, 2005). The same tools are also enabling marine microbiologists to deduce organism function, permitting the identification of previously unknown classes of life, such as anaerobic bacteria with photosynthetic capabilities. We cannot confidently predict the trajectory of our climate without understanding these organisms.

In Situ Power and Communication: Scientists can increasingly work in the remote and hostile ocean environment from their desks, through the innovative technology of networks of distributed sensors, both mobile and fixed to the seafloor. One of the largest technical initiatives in the ocean sciences will deploy thousands of kilometers of cables capable of delivering kilowatts of power and internet connectivity to the seafloor (National Research Council, 2000 and 2003). Large moorings are being designed that will generate power and act as communication gateways to more remote locations, connecting satellite communications to instruments on the seafloor. The benefits will accrue to a broad range of ocean activities, for example enabling laboratory experiments on the seafloor, and the detection of potentially catastrophic events such as earthquakes, submarine landslides, and approaching tsunamis.

The Cyber Ocean: The increased volumes, quality, and diversity of data coupled with rapidly improving ocean models are creating opportunities for understanding the ocean as never before. These data collection efforts are increasingly matched with efforts to create comprehensive systems for management, visualization, and interpretation of data (NSF Cyberinfrasture Council). The sophisticated physics-based models used for prediction of ocean conditions are evolving to take advantage of data availability, and to in turn make their results available rapidly via the internet. A key feature of future portals is that they must enable citizen and scientist alike, allowing the general public, resource managers, educators, researchers, government entities and business interests to access data and information tailored to their needs.

Summary

Ocean technology is enabling the development of ocean platforms and sensors to understand natural ocean processes and the risks associated with human impacts on the ocean. If our planet is like an automobile, and our climate like a highway, we have started our car racing down that road in the dark. We have too little ability to predict the hazards ahead – we have low beams; we need brights. Many threats have been identified such as shutdown of the ocean circulation (Stocker, 1991), coastal inundation (IPCC Synthesis Report, 2007), loss of habitats such as coral reefs (Bellwood et al., 2004), collapse of fisheries (Meyers and Worm, 2003), and declines in ocean productivity (Behrenfeld, 2006), but their severity is uncertain, and our ability to predict them is nearly non-existent due to inadequate understanding. Thus a central focus of the technological enterprise is to develop the tools to enable predictive skill – to build the bright headlights. This encompasses a range of activities from supporting fundamental investigations of ocean processes, to the development of integrated ocean observing and prediction systems to give advance warning of serious change. With the ability to see the road ahead, we can rationally evaluate strategies to avoid or at least mitigate catastrophic change.

References

Anderson, D.M., P.M. Gilbert, and J.M. Burkholder (2002). Harmful algal blooms and eutrophication: Nutrient sources, composition, and consequences. *Estuaries* 25:704-726.

Bindoff, N.L. et al. (2007). Observations: Oceanic climate change and sea level, *Climate Change 2007: The Physical Science Basis.* Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, edited by S. Solomon et al, pp. 385-432, Cambridge University Press, New York.

Barber R.T. and F.P. Chavez (1983). Biological consequences of El Niño. *Science* 222:1203–1210.

Barry, J.P., C.H. Baxter, R.D. Sagarin, and S.E. Gilman (1995). Climate-related, long-term faunal changes in a rocky intertidal community. *Science*, 267(5198) 672-675.

Barry, J.P., K.R. Buck, C.F. Lovera, L. Kuhnz, P.J. Whaling, E. T. Peltzer, P. Walz, and P.G. Brewer (2004). Effects of Direct Ocean CO_2 Injection on Deep-Sea Meiofauna. *Journal of Oceanography*, 60: 759-766.

Behrenfeld M.J., R.T. O'Malley, D.A. Siegel, C.R. McClain, J.L. Sarmiento, G.C. Feldman, A.J. Milligan, P.G. Falkowski, R.M. Letelier, and E.S. Boss (2006). Climate-driven trends in contemporary ocean productivity. *Nature* 444:752-755.

Bellingham, J.G., and K. Rajan (2007). Robotics in Remote and Hostile Environments. *Science* 318:1098-1102.

Bellwood, D.R., T.P. Hughes, C. Folke, and M. Nystrom (2004). Confronting the coral reef crisis. *Nature*, 429:827-833.

Brewer, P.G. (1997). Ocean chemistry of the fossil fuel CO_2 signal: the haline signature of "Business as usual." *Geophysical Research Letters*, v. 24, 1367-1369.

DeLong, E.F. and D.M. Karl (2005). Genomic perspectives in microbial oceanography. *Nature* 437:336-342.

Dodds, W.K. (2006). Nutrients and the "dead zone": the link between nutrient ratios and dissolved oxygen in the northern Gulf of Mexico. *Frontiers in Ecology and the Environment,* 4(4): 211–217.

Donner, S.D. and C.J. Kucharik (2008). Corn-based ethanol production compromises goal of reducing nitrogen export by the Mississippi River. *Proceedings of the National Academy of Sciences,* 105, 45613-4518.

EPA. (2007). Hypoxia in the northern Gulf of Mexico, an update by the EPA Science Advisory Board. EPA-SAB-08-003. (http://www.epa.gov/sab).

Fleming, L.E, J. Eason, D. Baden, A. Rowan, and B. Levin (1999). Emerging Harmful Algal Blooms and Human Health: Pfiesteria and Related Organisms, *Toxicologic Pathology*, 27:573-581.

Field, C., M. Behrenfeld, J. Randerson, and P. Falkowski (1998). Primary Production of the Biosphere: Integrating Terrestrial and Oceanic Components. *Science*, 281:237-240.

Given S., L.H. Pendleton, and A.B. Boehm (2006). Regional public health cost estimates of contaminated coastal waters: A case study of gastroenteritis at Southern California beaches. *Environmental Science & Technology*, 40, 4851 – 4858.

Hansen, J.E. (2007). Scientific reticence and sea level rise. *Environmental Research Letters,* 2, 1-6.

Hoegh-Guldberg, O., P.J. Mumby, A.J. Hooten, R.S. Steneck, P. Greenfield, E. Gomez, C.D. Harvell,P.F. Sale, A.J. Edwards, K. Caldeira, N. Knowlton, C.M. Eakin, R. Iglesias-Prieto, N. Muthiga, R.H. Bradbury, A. Dubi, M.E. Hatziolos (2007). Coral Reefs Under Rapid Climate Change and Ocean Acidification. *Science* 218:1737-1742.

IPCC (2007). *Climate Change 2007: Fourth IPCC Assessment Report:* Synthesis Report. (http://www.ipcc.ch/ipccreports/ar4-syr.htm).

Ishimatsu, A., T. Kikkawa, M. Hayashi, K. Lee, J. Kita (2004). Effects of CO_2 on Marine Fish: Larvae and Adults. *Journal of Oceanography* [J Oceanogr] Vol 60:no. 4.

Ishimatsu A., M. Hayashi, K-S. Lee, T. Kikkawa, J. Kita (2005). Physiological effects on fishes in a high-CO_2 world. *Journal of Geophysical Research C Oceans* [J Geophys Res (C Oceans)] Vol 110:no. C9.

Johnson, K.S., J.A. Needoba, S.C. Riser, W.J. Showers (2007). *Chem. Rev.* 107:623.

Knoll, A.H., R.K. Bambach, J.L. Payne, S. Pruss, W.W. Fischer (2007). Paleophysiology and end-Permian mass extinction. *Earth and Planetary Science Letters,* 256: 295-313.

Laws, E. (2008). Background Oceanography. In: *Oceans and Human Health. Risks and Remedies from the* Sea (Eds. P.J. Walsh, S.L. Smith, L.E.Fleming, H.M. Solo-Gabriele, W.H. Gerwick). Elsevier, Inc., Oxford, U.K. pp 3-20.

Matthews, H.D. and K. Caldeira (2007). proc. *Natl. Acad. Sci.* USA, 104, 9949-9954.

Myers, R.A. and B. Worm (2003). Rapid worldwide depletion of predatory fish communities. *Nature*, 423:280-283.

National Ocean Economics Program (2006). www.Ocean-Economics.org, U.S. Bureau of Labor Statistics.

National Research Council (2000). *Clean Coastal Waters: Understanding and Reducing the Effects of Nutrient Pollution.* National Academies Press, 405 pp.

National Research Council (2000). *Illuminating the Hidden Planet: The Future of Seafloor Observatory Science.* Washington, D.C., National Academy Press, 135 pp. (www.nap.edu/catalog/9920.html).

National Research Council (2003). *Enabling Ocean Research in the 21st Century: Implementation of a Network of Ocean Observatories.* Committee on the Implementation of a Seafloor Observatory Network for Oceanographic Research, Washington, D.C., National Academy Press, 224 pp.

North, G.R. (1984). The Small Ice Cap Instability in Diffusive Climate Models. *Journal of Atmospheric Science* 41:3390–3395.

NSF Cyberinfrastructure Council (2006). NSF's Cyberinfrastructure vision for 21st Century Discovery, National Science Foundation, Version 7.1, (http://www.nsf.gov/od/oci/ci-v7.pdf).

Orr, J.C., et al., (2005) Anthropogenic Ocean Acidification over the twenty-first century and its impacts on calcifying organisms. *Nature* 437, 681-686.

Pörtner, H.O., M. Langenbuch, and B Michaelidis (2005). Synergistic effects of temperature extremes, hypoxia, and increases in CO_2 on marine animals: From Earth history to global change. *Journal of Geophysical Research* 110, CO9S10.

Rabalais, N.N., R.E. Turner, and D. Scavia (2002). Beyond science into policy: Gulf of Mexico hypoxia and the Mississippi River. *BioScience* 52: 129-142.

Ramsdell, J.S., D.M. Anderson, and P.M. Glibert (Eds.) (2005). *Harmful Algal Research and Response: A National Environmental Science Strategy 2005-2015.* Ecological Society of America, Washington, D.C., 96pp.

Rowley, R.J., J.C. Kostelnick, D. Braaten, X. Li and J. Meisel (2007). Risk of rising sea level to population and land area. *EOS, Transactions of the American Geophysical Union,* 88, 105-107.

Sabine, C.L. et al. (2004). The oceanic sink for anthropogenic CO_2. *Science*, 305, 367- 371.

Sandifer, P., C. Sotka, D. Garrison, and V. Fay (2007). Interagency Oceans and Human Health Research Implementation Plan: A Prescription for the Future. Interagency Working Group on Harmful Algal Blooms, Hypoxia, and Human Health of the Joint Subcommittee on Ocean Science and Technology. Washington, DC.

Santo Domingo, J.W. and J. Hansel (2008). Waterborne Diseases and Microbial Quality Monitoring for Recreational Water Bodies Using Regulatory Methods. In: *Oceans and Human Health. Risks and Remedies from the Sea* (Eds. P.J. Walsh, S.L. Smith, L.E.Fleming, H.M. Solo-Gabriele, W.H. Gerwick). Elsevier, Inc., Oxford, U.K. pp 337-357.

Sheppard, P.R., A.C. Comrie, G.D. Packin and K. Angersbach (2002). Climate of the US Southwest. *Climate Research* 21:219-238.

Stocker T.F. and D.G. Wright (1991). Rapid transitions of the ocean's deep circulation induced by changes in surface water fluxes. *Nature* 351:729–732.

Stramma, L., G.C. Johnson, J. Sprintall, and V. Mohrholz (2008). Expanding Oxygen-Minimum zones in the tropical oceans. *Science* 320: 655-658.

Turner, R.E., N.N. Rabalais, R.B. Alexander, G. McIsaac and R.W. Howarth (2007). Characterization of nutrient, organic carbon and sediment loads from the Mississippi River into the northern Gulf of Mexico. *Estuaries and Coasts* 30(5): 773-790.

Appendix B: Summit Overview

Ocean Science Summit 2008: Climate Change and Ocean Health

Monterey Bay Aquarium Research Institute (MBARI)
Monterey and Moss Landing, CA
May 27 — 29, 2008

In celebration of the tenth anniversary of the United Nations' Year of the Oceans, the Monterey Bay Aquarium Research Institute (MBARI) is hosting the 2008 Ocean Science Summit: Climate Change and Ocean Health.

The Summit will bring U.S. Senators and Members of the House of Representatives and their professional staff together with an unprecedented community of leading marine and coastal scientists to highlight the dramatic advancements in our understanding of the ocean environment over the last decade and to spotlight the rapidly emerging challenges illuminated by these discoveries. One of the most urgent challenges facing the oceans today is the suite of impacts associated with increased levels of atmospheric carbon dioxide such as climate change and ocean acidification.

Goals of the Summit:

The Ocean Science Summit will be a gathering of leading ocean scientists, federal legislators, and policy makers designed to ensure that the latest and most policy-relevant scientific information informs important national decisions at this time of growing environmental challenges and scientific opportunities. To this end, we shall:

1. Identify science and legislative strategies to support ocean health in the coming decades.
2. Share growing knowledge about the rapid atmospheric CO_2-driven changes underway in the oceans.
3. Explore the uses of cutting edge technologies furthering understanding of complex ocean system dynamics.
4. Assess mitigation and social adaptation initiatives for atmospheric CO_2-driven ocean changes.

Participants:

This is an invitation only event. Attendance at the Summit will be limited. Invitees to the Summit are elected officials from the U.S. Senate and the U.S. House of Representatives with committee-related assignments to oceans, science and/or climate change matters; professional Hill Staff from personal and committee offices with ocean, science, and/or climate change related portfolios; representatives from select Executive Branch departments; distinguished ocean scientists from throughout the nation; and other leaders in the ocean community.

Summit Format:

The attendance will be small to provide for both thorough roundtable and panel discussions, and hands-on experiential activities aboard research vessels and shoreside exploration in and around Monterey Bay. Opening with distinguished leaders in the ocean community, this two-day event will provide an overview of the state of our oceans, and pose questions and solutions that together Summit scientists and policy makers will discuss during the remainder of the meeting. This format will highlight valuable and diverse points of view between the science and policy communities regarding the crucial issues that confound us today, strive to bring greater understanding to these diverse perspectives, and to integrate these perspectives into effective recommendations for policy-relevant scientific inquiry and evidenced-based policy development. Participants also will discuss recommendations for action to strengthen our collective ability to meet the challenges in the future. Based on discussions at the Summit a list of scientific and legislative needs, along with next steps for meeting these needs will be generated. (Detailed Summit agenda is attached.)

Summit Topics:

The following topics will be addressed at the Summit.

- Managing and mitigating risks from ocean changes related to climate change: ocean acidification, increasing sea temperature, and sea level rise.

- Addressing coastal impacts that exacerbate atmospheric CO_2-driven changes and that threaten ocean and human health from runoff, harmful algal blooms, and other causes.
- Matching ocean technologies with emerging national priorities: new technologies to support science that fuel American competitiveness.

Sponsorship:

The 2008 Ocean Science Summit is offered by MBARI, a nonprofit Private Foundation, and co-sponsored by MBARI and the NOAA National Marine Sanctuary Program with the American Association for the Advancement of Science (AAAS) and the California Council on Science and Technology (CCST) as coordinating partners.

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Appendix C: Summit Agenda

Day 1: Tuesday, May 27, 2008 **Location: Portola Hotel & Spa, Monterey, CA** **Dress: Business casual**

Time	Action
6:00 to 8:00 pm Portola Room	Registration/Welcome Reception/Opening Program • Judith Kildow, Summit Chair, MBARI

Day 2: Wednesday, May 28, 2008 **Location: Portola Hotel & Spa, Monterey, CA** **Dress: Business casual**

Time	Action
8:00 to 8:30	Continental Breakfast and Check In
8:30 to 9:00 DeAnza III	MBARI Introduction and Overview by Hosts Judith Kildow, Summit Chair, MBARI Marcia McNutt, President and CEO, MBARI Welcome by CA House and Senate officials Congressman Sam Farr, California Senator Barbara Boxer, California (video greeting)
9:00 to 9:30 DeAnza III	Keynote: Innovations in Ocean Management • Mike Chrisman, Secretary, CA Resources Agency
9:30 to 10:30 DeAnza III	Panel Discussion: Achievements in Ocean Governance • Oceans and Climate Change • Ocean Health and Land/Sea Interactions • Ocean Technologies and America's Competiveness • Co-Chair: Senator Sheldon Whitehouse, Rhode Island • Co-Chair: VADM Conrad Lautenbacher, Under Secretary, US Department of Commerce National Oceanic and Atmospheric Administration • Michael Conathan, Senate Committee on Commerce, Science, and Transportation • Daniel Walker, Senior Policy Analyst, Office of Science, Technology & Policy, White House
10:30 to 10:45	Break
10:45 to 11:15 DeAnza III	Keynote: Innovations in Marine Science and Technology • John Hanke, Director, Product Management Google Maps, Local, and Earth

Day 2: Continued

Time	Action
11:15 to 12:15 DeAnza III	Panel Discussion: Achievements in Marine Science and Technology • Oceans and Climate Change • Ocean Health and Land/Sea Interactions • Ocean Technologies and America's Competiveness • Chair: Robert Gagosian, Consortium for Ocean Leadership • Shirley Pomponi, Chair, NAS Ocean Studies Board; Vice President Director, Harbor Branch Oceanographic Institution • James Bellingham, Chief Technologist, MBARI • Richard Spinrad, Assistant Administrator for Research, NOAA Office of Oceanic and Atmospheric Research
12:15 to 12:30	Break
12:30 to 2:00 DeAnza I	Lunch with Panel: *Investing in our Oceans* • Oceans and Climate Change • Ocean Health and Land/Sea Interactions • Ocean Technologies and America's Competiveness • Chair: Julie Packard, Executive Director, Monterey Bay Aquarium • Julie Morris, Division Director, Oceanographic Sciences, NSF • Brian Baird, Assistant Secretary of Ocean & Coastal Policy, CA Resources Agency • Barry Gold, Marine Conservation Lead, Moore Foundation • Jay Pearlman, IEEE CEO chair and GRSS Advisory Cte member
2:00 to 4:00 With short break	Roundtable Deliberations 6 break-out rooms with Moderators and Scribes • Oceans and Climate Change • Oceans and Climate Change and Ocean Technology • Ocean Health and Land/Sea Interactions • Ocean Health and Land/Sea Interactions and Technology
4:00 – 4:15	Break
4:15 to 5:15 DeAnza III	Plenary Session Roundtable Report-out • Meg Caldwell, Interim Director, Center for Ocean Solutions, and Roundtable Moderators Perspectives from Capitol Hill • Congresswoman Lois Capps, California
5:15 to 5:30 DeAnza III	Logistics and plans for next day • Judith Kildow, Summit Chair, MBARI
5:30	Adjourn
6:30 to 9:30 Monterey Bay Aquarium	Dinner/ Reception at Monterey Bay Aquarium Speakers: Julie Packard, Executive Director, Monterey Bay Aquarium Sylvia Earle, Oceanographer, Entrepreneur, Author

Day 3: Thursday, May 29, 2008 **Location: At sea and Moss Landing, CA** **Dress: Casual (and warm)**

Time	Action
6:30 to 7:15	Breakfast
Meet in Portola Lobby for Departure	Shuttles to ships' departure locations • 7:15 AM Moss Landing • 7:30 AM Monterey • 8:00 AM Land Tour
8:00 to 11:30	Hands-on Field Experience aboard a vessel or on land • Oceans and Climate Change • Ocean Health and Land/Sea Interactions • Coastal Impacts • Land Sea interactions: MLML vessel *R/V John H. Martin* • Near Shore Issues: Monterey Bay Aquarium vessel Derek *M. Baylis* • Land Sea Interactions: Elkhorn Slough Safari Boat Tour • Shoreline changes: Land Tour with Professor Gary Griggs • MBNMS vessel *R/V Fulmar* ROV experiments – Mid-water experiments • Deep water ROV dives and Ocean Changes: MBARI vessel *R/V Pt. Lobos*
11:30 to 12:30	Lunch at Moss Landing
1:00 to 1:45 Pacific Forum	Plenary Session • Peter Seligmann, CEO and Chairman, Conservation International – Science for Stewardship Charge to participants for afternoon / logistics • Judith Kildow, Summit Chair, MBARI
1:45 to 3:15 With short break	Roundtable Deliberations and Clarifying Recommendations 6 break-out rooms with Moderators and Scribes • Oceans and Climate Change • Oceans and Climate Change and Ocean Technology • Ocean Health and Land/Sea Interactions • Ocean Health and Land/Sea Interactions and Technology 3:30 – 4:00 Moderators summarize roundtable
3:15 to 4:00	Break
4:00 to 5:15 Pacific Forum	Plenary: Frame the Vision for the Future and Roundtable Report-out • Meg Caldwell, Interim Director, Center for Ocean Solutions, and Roundtable Moderators • Oceans and Climate Change and Ocean Technology • Ocean Health and Land/Sea Interactions and Technology Panel Discussion • Mike Sutton, Vice President, Monterey Bay Aquarium • Leon Panetta, Director, Panetta Institute • Marcia McNutt, President, CEO, MBARI • Congressman Sam Farr

Day 3: Continued

Time	Action
5:15 to 5:30 Pacific Forum	Next Steps / Recommendations / Resolution and Closing • Judith Kildow, Summit Chair, MBARI
5:30	Adjourn
5:30 to 6:30 MBARI dock	Closing Reception and fact finding tour of research vessels and related programs • ***R/V Zephyr***: primary support vessel for MBARI's Autonomous Underwater Vehicle (AUV) program. • ***R/V Pt. Sur***: NSF vessel, part of the national research, will be fleet fully loaded for a research cruise.
6:30	Shuttles depart for hotel

Friday, May 30, 2008

Time	Action
Morning	Departure

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Appendix F: Ocean Science Summit Workshop Overview and Agenda

Pre-Summit Training

Marine scientists and engineers underwent an intensive two-day Communications workshop one month prior to the Ocean Science Summit in Monterey (see agenda below). The goal of the Communications Training was to prepare scientists and engineers to:

- Effectively communicate their research findings to policy-makers who attend the conference;
- Create policy-makers interest in, and excitement about, ocean research and exploration;
- Explain the state and importance of the world's ocean in ways that will resonate with the target policy audience; and
- Successfully establish themselves as useful resources for the policy-makers who attend the conference.

The two-day training consisted of three sections: 1) understanding the policy audience; 2) communicating research and science to non-scientific audiences and making your scientific messages memorable; 3) and strategic performance.

The first session, understanding your policy audience, was lead by the Communication Partnership for Science and the Sea (COMPASS). COMPASS explored the basics of what makes federal policy-makers "tick" by delving into discussions about what their day-to-day work is like, what they care about, and what will resonate with them. The COMPASS trainers also reviewed some relevant and pending legislation that related to the ocean, climate change, and technology and research.

The second session, making your scientific messages memorable, was lead by Ashley Simons of Stanford University. The scientists learned new techniques to explain their work in ways that would resonate with policy makers. The scientists split into three groups based on their expertise: a) climate change and the ocean, 2) land-sea connections, and 3) ocean technology, themes for the upcoming Summit. Each group had some time to work together to develop the main overarching messages they wanted to get across to policy-makers. However, time at the training was limited for this discussion. The trainer then led the scientists through various exercises simulating discussions with policy-makers providing strategies for making their messages "stick."

Nancy Houfek and Lee Warren of Harvard University led the third session, strategic performance. These professionals explored the roles of different people in different situations, and how any person in any situation can be a leader for change. They worked with the scientists showing them how to use body language, their voice, and metaphors to be effective and successful in any social or professional situation.

Scientists' response to training

Experts in the Summit's three focal areas (the oceans and climate change, land-sea interaction, and emerging ocean technologies) gathered from across the nation for this workshop. While the majority who participated found that it helped them to better understand the policy world , there was a tension between the those who felt the need to focus more on the science and those who wanted to hone communications skills. With limited time, the facilitators focused on the latter, while other scientists felt their time would have been better spent discussing with each other the most pressing issues to get across to the policy-makers.

Changes underway in the oceans will create significant societal dislocations within decades. Yet, ocean scientists have not had the ear of legislators and policy makers. The have neither gotten sufficient funds to track down answers to important questions which would give greater understanding of these changes, nor have they been successful in bringing their evidence about these changes into the halls of power to encourage actions. The scientific world is a competitive environment. Competition for research funds, for publications and findings are ever present. However, the challenge for ocean scientists is to speak with one strong voice and a clear message when addressing a policy-making audience. Consensus on what is important and about priorities is essential to help inform legislative and policy decisions. The more people, interest groups and constituents who repeat the same message, the more policy-makers will hear it and feel they have the power to act on it.

In reality, learning to speak with one voice will take time. The scientists began that exercise at the pre-Summit workshop and briefing sessions. The training facilitated the beginning of the effort to help ocean scientists from various disciplines speak with one voice. That process was a valuable outcome of this exercise, which organizers encourage scientists to continue.

Workshop Agenda

DAY ONE – Thursday, April 24, 2008

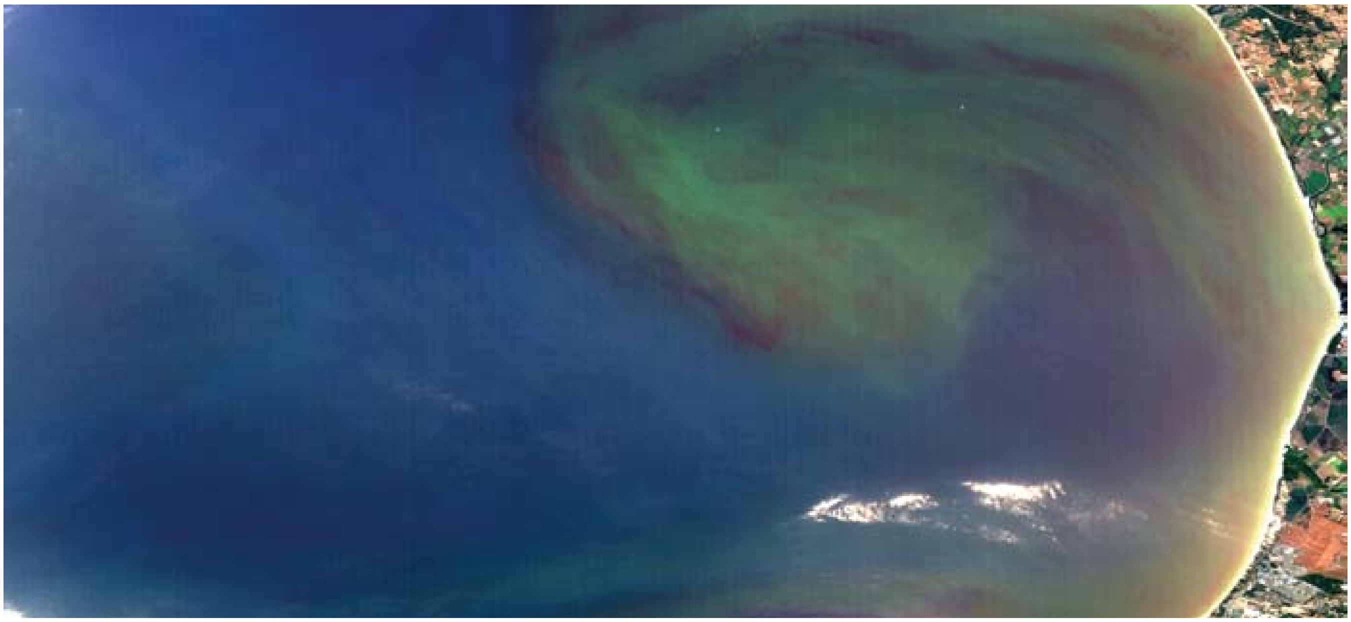
Time	Action
8:00-8:30	Continental Breakfast
8:30-8:40	Welcome and Opening Remarks (Judy Kildow)
8:40-9:15	Introductions (Judy Kildow) In 60 seconds or less, introduce yourself and the key message you hope to get across to policy-makers
9:15-10:15	Presentation: Know Your Audience – Understanding a Policy Maker's Worldview (Chad and Adina) *Basics of what makes federal policy-makers "tick". What do they care about? What will resonate with them? Review some Key Legislation that will be on these policy-makers' desks this year.* *Background on Policy Makers and Staff attending the Summit*
10:15-10:30	Break
10:30-11:30	Continuation: Presentation: Importance of Understanding Your Audience – Exploration of Policy Audience (Chad and Adina)
11:30-12:30	Make your Scientific Message Memorable (Ashley) *Learn and practice new techniques to explain your work in ways that will resonate with policy makers.*
12:30-1:30	Lunch and networking
1:30-2:30	Continue: Make your Scientific Message Memorable (Ashley)
2:30-5:00 With Break	Strategies for Leading Change, part I (Lee) *Introduction to adaptive/technical challenge distinctions and exercise in pairs and then full group* *Strategies for Leading Change, part 2 (Lee)* *Introduction to leadership/authority distinctions and case discussion, including discussion of factions/positions and raising the heat* *Role plays that mimic upcoming meetings*
5:00	Wrap-up / Q&A/ Prep for the next day (All)
7:00	Dinner at Montrio Bistro - Monterey

DAY TWO – Friday

Time	Action
8:00-8:30	Continental Breakfast
8:45-9:00	Welcome and Opening Remarks (Judy Kildow)
9:00-12:30 With Break	STRATEGIC PERFORMANCE (Nancy and Lee) *Ball throwing (Understand importance of two – way conversation, people need to be ready to hear information,)* *Purpose, de-Personalizing* *Role play one-on-one to mimic upcoming meetings* *Body Language, Charisma* *Managing Hot Moments, Allies & Confidants* *Role play group scene: Position, Preparation*
12:30-1:30	Lunch and networking
1:30-2:15	VOCAL POWER (Nancy) *Waking up the voice* *Vocal exercises to release tension* *Dynamic speaking* *Tactical speaking*
2:15-3:15	*USE OF METAPHOR (Nancy)* *Finding the metaphor or analogy that will unlock the difficult and complex concept for the listener*
3:15-3:30	Break
3:30-4:15	Perfecting your Elevator Pitch (Ashley) *Participants practice using crisp, concise messages in a timed scenario.*
4:15-5:00	Social Time: Wrapping it up and what happens now?

Appendix G: Hands-On Field Experiences

Ocean Health and Land-Sea Interactions



A brief venture into the Monterey Bay National Marine Sanctuary on the Research Vessel *John H. Martin*
May 29, 2008

The morning excursion will bring participants into beautiful Monterey Bay to:

- Observe coastal land use practices and discuss their effects
- Sample plankton at the base of the food chain and see how they are affected by land-sea interactions
- Survey marine mammals and birds and examine the complex linkages between land-sea interactions and higher animals

Upon docking, participants will be transported to Moss Landing Marine Laboratories for a hands-on tour through the world of plankton. In a new microscopy lab, phytoplankton experts will help participants identify organisms and point out species of special interest. Lunch to follow.

Near-Shore Issues: Sailing vessel *Derek M. Baylis*

Sailing Vessel *Derek M. Baylis*
Ocean Science Summit
May 29, 2008

The Derek M Baylis is a 65-foot sailboat designed for ocean research. The vessel takes its name from an engineer that helped shaped both the Monterey Bay Aquarium (MBA) and Monterey Bay Aquarium Research Institute (MBARI). In addition to his many contributions to both organizations, Derek is the patriarch of one of America's best-known competitive sailing families. A trip on the Derek M Baylis is thus more than sailing excursion. It is a tribute to man who helped David Packard realize his vision for creating a portal to the ocean for the general public as well as research scientists and engineers.

We will meet on historic Fisherman's wharf in Monterey at 7:30AM and depart by 8:00. The ship will sail along the storied Monterey Peninsula. You'll get your hands wet collecting water samples and viewing plankton under a microscope, and observing some of the fascinating bottom-dwelling creatures that live in the shallows. Along the way you may also get to see whales, dolphins and sea otters, all common visitors to the bay. You'll learn about the history of the Monterey Bay National Marine Sanctuary, how this resource-rich environment has been utilized and studied over the years, and how it can serve as a natural laboratory in the future.

This promises to be a rare view of the bay and the amazing creatures that live there. Everyone can take a turn at the helm steering the boat and you'll have an opportunity to learn about navigation and sailing.

We will return to Fisherman's wharf at approximately 11:00AM. Transportation will be provided back to Moss Landing where we'll enjoy lunch and then engage in the roundtable discussions.

Land Sea Interactions: Elkhorn Slough Safari Boat Trip

Ocean Summit
Monterey, CA
May 29, 2008

Elkhorn Slough Field Trip Guide: A Case Study in Multi-Jurisdictional, Ecosystem-Based Management

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Introduction

The Elkhorn Slough field trip will use the Slough Safari pontoon boat for a several hour trip. It can get chilly so bring your fleece jacket and a hat.

Elkhorn Slough is a 10-km long estuary at the head of Monterey Bay. The slough harbors the largest tract of salt marsh in California outside of San Francisco Bay and is a remarkable coastal environment. It encompasses extraordinary biological diversity in a small area and has been the

focus of conservation activities for nearly four decades. The importance of Elkhorn Slough as a conservation target is reflected in the designations nested in the slough:

- National Estuarine Research Reserve
- California State Ecological Reserve
- State Wildlife Management Area
- Nature Conservancy Preserve
- National Marine Sanctuary
- Audubon Globally Important Bird Area
- Western Hemisphere Shorebird Reserve
- California Department of Parks and Recreation, State Beach
- Land Trust Reserve

See http:/www.elkhornslough.org

The slough has also been the focus of a variety of research projects since the 1920's. The Elkhorn Slough National Estuarine Research Reserve (ESNERR) lies on the eastern shore of the slough and has focused attention on marsh

loss through a major initiative. Supporting this work, and contributing to our understanding of biogeochemistry, is the installation by MBARI of a novel, wireless chemical sensor network. This Land/Ocean Biogeochemical Observatory (LOBO - funded by the NSF Biocomplexity in the Environment program and MBARI), monitors the waters and ecosystem processes with a resolution unparalleled anywhere else in the coastal ocean. Data are delivered directly to the Internet (http:/www.mbari.org/lobo) where they are used for research, teaching and management. The LOBO system has grown from its Elkhorn Slough origins and nodes are spreading across North American estuaries to form a continental scale observing system for estuarine biology and chemistry.

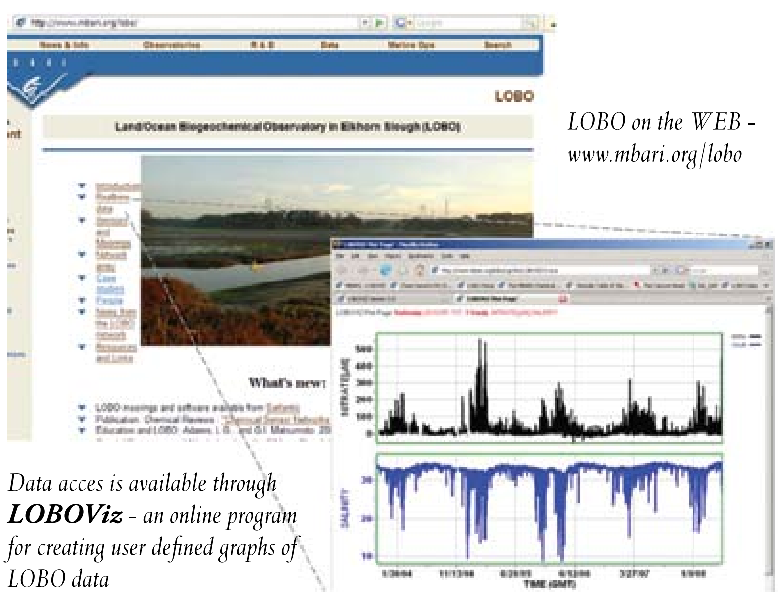
Over the past several decades tens of millions of dollars have been expended to conserve, protect and restore the estuary, its watershed and the myriad species that depend

on this environment. Elkhorn Slough has been a convenient laboratory to test ideas of how we, as a society, balance the economic and social needs of a 'working landscape' with sustaining a rare and remarkable complex of habitats. There has been great progress, yet many significant challenges remain. There is a web of partnerships and processes that are tackling some of these challenges at the intersection of science and management. Two of the vexing, and intertwined issues currently addressed are the loss of tidal marshes and the inputs of nutrients to the estuary.

Human impacts

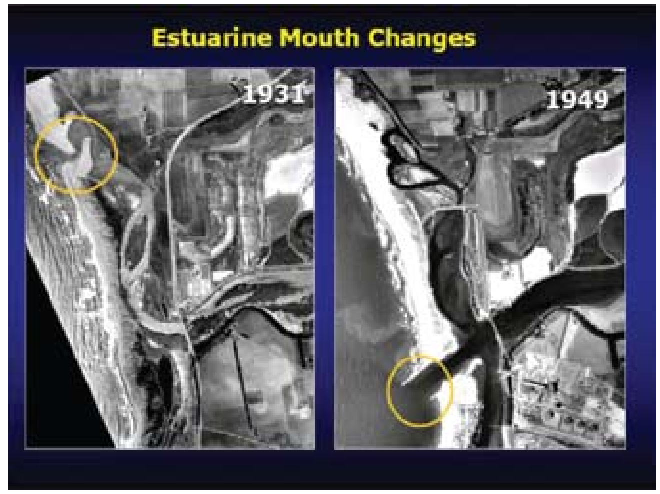
Monterey County is aptly named the lettuce bowl of America. It produces crops with a value near $3.5 billion, the highest of any U.S. county. As the fertilizers that support these crops are carried off the land, they create near-record nutrient concentrations in some areas of the Slough. These nutrients can produce dense algal mats. Oxygen consumption rates by organisms feeding in the sediment are among the highest ever recorded. Slough waters become strongly oxygen depleted at night, particularly in summer.

Construction of the Moss Landing Harbor in 1946 dramatically altered the nature of the Slough by moving its mouth about 1 km south, and placing it in line with the main channel axis. This allowed current velocities to increase many-fold as the tide falls. These strong currents are now rapidly eroding the Slough banks. The depth of the main channel has increased from about 2 meters in 1940 to 8 meters today due to this erosion.



LOBO on the WEB – www.mbari.org/lobo

*Data acces is available through **LOBOViz** – an online program for creating user defined graphs of LOBO data*



The LS Power, Inc. power plant, located on the Slough, produces 2560 MegaWatts of electrical power. It is the largest fossil fuel power plant in California. The power plant consumes enough cooling water each day to nearly equal half the Slough volume.

Ecosystem-based management

Many of the tourists to the slough are awed by the diversity and concentrations of wildlife but unaware of the environmental challenges that are present. Fifty percent (1,000 acres) of Elkhorn Slough's salt marshes have been lost over the past 150 years due to human-induced changes in slough hydrology. Channel bank erosion rates reach 6 meters per decade. These rapid changes not only affect the estuary's animals and plants, but also impact public access sites and railroad and road infrastructure. However, the high water velocities that drive much of the erosion also provide a positive benefit. Strong currents rapidly flush much of the algae and oxygen depleted water into Monterey Bay, where energetic mixing disperses it. This rapid flushing mitigates much of the impact that would otherwise result from the high nutrient concentrations in Slough waters.

These, sometimes conflicting, uses of the environment and their impacts make Elkhorn Slough a natural laboratory for integrating environmental management and science in a multi-jurisdictional framework. Further, the problems of coastal erosion and excess nutrients are challenges faced by coastal areas across the U.S. Loss of wetlands

Azevedo Pond, on the fringe of the slough, in 1994 and in 1998 after restoration.

contributes to the impending danger of tropical storms in the southeastern US. Loss of oxygen that is driven by excess production of phytoplankton biomass impacts water bodies from Chesapeake Bay to the northern Gulf of Mexico to Puget Sound. Although the Slough lies within a single county, the regulatory framework is complex. Some 15 local, State and Federal agencies have jurisdictional or permitting authority over activity within the Slough.

Ecosystem restoration has been an ongoing focus in the Slough for the past 25 years. These activities are led by the Elkhorn Slough Foundation with support from the Packard Foundation, Nature Conservancy and other non profits and the National Estuarine Research Reserve and California Department of Fish and Game. Over 7,000 acres of land, about 15% of the watershed, have been protected from development. Much of the protected land on the borders of the Slough has been restored to a state that minimizes the impacts of development throughout the remainder of the watershed.

We have come to understand that the historic human-induced changes, particularly tidal erosion from harbor construction and excessive nutrient inputs, threaten the system from one side and that jeopardy from narrow solutions to these problems, with possible unintended consequences, threaten from the other. To address these intertwined issues a broadly based group of environmental managers, scientists and regulators have implemented an ecosystem-based management program. Supported by the Packard Foundation, this project brings cutting edge technology for mapping and monitoring key elements of the system and a cadre of experts from the physical, natural and social sciences and environmental economists. Elkhorn Slough provides an outstanding opportunity to apply the principles of ecosystem-based management to a high profile environment and to evaluate alternate strategies for addressing issues of concern. The outcome of this effort will be the selection of conservation actions to arrest the degradation of Slough habitats and to restore these habitats and ecosystem functions, with support of all key stakeholders.

OCEAN SUMMIT
Monterey, California
May 29, 2008

COASTAL FIELD TRIP ON SHORELINE CHANGE AND HAZARDS ALONG THE SOUTHERN MONTEREY BAY SHORELINE

Gary Griggs
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COASTAL FIELD TRIP ON SHORELINE CHANGE SOUTHERN MONTEREY BAY

PHYSICAL AND GEOLOGICAL SETTING

For social, recreational, economic, and environmental reasons, the coast of southern Monterey Bay is among the region's most prized natural resources. The beaches offer recreational activities and economic opportunities to Monterey Bay residents and visitors; they afford a natural barrier that helps to protect the shoreline during storm events; they provide habitat for numerous shorebirds, including critical habitats for threatened or endangered species; and they are desirable places to live near, increasing property values and revenue for the community. Due to a persistent rise in sea level, changes in sand availability due in large part to a long history of sand mining from the beach, and previous unsustainable public and private development practices, the southern Monterey Bay coastal dunes and beaches south of the Salinas River are eroding, on average, at the fastest rate in California. Erosion compromises the ability of the dunes and beaches to buffer the oceanfront development and infrastructure from storms and flooding, to provide vital natural habitat, and to successfully accommodate recreation and tourism.

The retreat of the southern Monterey Bay shoreline creates complex management problems: property owners want to protect their homes and businesses; municipalities want to protect their tax base and infrastructure; environmental groups want to preserve habitat and minimize damage to the dunes and beaches; and resource managers want to balance public access and habitat protection.

Monterey Bay is a lowland coastal embayment, bounded by resistant rock headlands at its north (Santa Cruz) and south (Monterey) ends (Figure 1). The shoreline between the Salinas River mouth and Monterey is mainly composed of wide sandy beaches backed by relict (approximately 5,000 to 3,000 years old) sand dunes up to five miles wide and 150 feet high. The seaward face of the sand dunes is an eroding bluff.

Approximately 18,000 years ago, at a lower stand of sea level, the dunes extended seven miles seaward of the present day shoreline. Historically, the beaches of southern Monterey Bay were supplied by large volumes of sand from the watershed of the Salinas River, when the river had a much steeper gradient and a larger transport capacity for sediments. The abundant sand in combination with dominant onshore winds created an extensive dune field in southern Monterey Bay. During the Flandrian (last 10,000 years) the shoreline eroded in response to sea level rise, migrating landward to its present position at an average erosion rate of approximately 2.3 ft/year. This value is a rough measure of the average erosion rate due to natural causes such as sea-level rise.

Figure 1. Monterey Bay showing terrestrial topography and offshore features (MBARI).

EROSION OF THE DUNE FACE OR COASTAL BLUFF

While the smooth regular curve of the shoreline of southern Monterey Bay would suggest a long-term dynamic equilibrium, it has been obvious for many years that the face of the older dunes has been experiencing wave eroding, producing a steep bluff face (Figure 2). Long-term erosion of the dunes has been previously measured using a variety of techniques and references.

Bluff or cliff erosion rates have recently been determined along the entire California coastline as part of a nation-wide Shoreline Change Assessment being conducted by the US Geological Survey (Hapke). Local site-specific Monterey Bay measurements have been carried out by scientists at the Naval Postgraduate School (Thornton) and CSU Monterey Bay (Gref). Average erosion rates were calculated by the USGS for two different periods, between 1910 and 2002 and between 1970 and 2002. The mean erosion rate from 1970 to 2002 of 4.0 ft/year for southern Monterey Bay between the Salinas River mouth and Monterey was the highest for the entire state of California.

Due to wave refraction patterns, in large part due to the most common direction of winter wave approach and the presence of Monterey Submarine Canyon, the bluff erosion rates vary along the shoreline of Southern Monterey Bay as follows:

- Marina-Marine State Beach: ~ 5.4 ft/yr (1976-2004) (Figure 3).
- Ft. Ord-Stillwell Hall: ~6.5 ft/yr (1976-2004) (Figure 4).
- Sand City-Monterey Beach Hotel: 5.1 ft/yr (1976-2004) (Figure 5).
- Del Monte Beach-Ocean Harbor House Condos: 2.3 ft/yr (1976-2004) (Figure 6).

Erosion of the southern Monterey Bay shoreline is not a consistent or regular process but occurs episodically. Large amounts of erosion have occurred during El Niño winters, followed by several 'regular' years producing less erosion, all of which can be summed to provide an average erosion trend. At Fort Ord, most of the recent erosion occurred during the El Niño events of 1982-83 and 1997-98, with the beaches eroding and then recovering. Response to the very high erosion rates at Stillwell Hall over the last several decades has consisted of dumping rock and concrete on the beach until it became clear that the structure would become a peninsula (Figures 7 and 8). In 2003 the building was removed and the shoreline is now coming back into equilibrium (Figure 9).

Figure 2. Eroded faces of older dunes along Southern Monterey Bay shoreline

SEDIMENT SINKS OR LOSSES

Potential sand sinks in the southern Monterey Bay littoral cell include Monterey Submarine Canyon, removal by wind onto adjacent active dunes, offshore transport onto the continental shelf during winter storms, and a very large human impact, sand mining from the beach (currently only occurring in Marina).

Monterey Submarine Canyon

Monterey Submarine Canyon marks the boundary between the Santa Cruz littoral cell and the southern Monterey Bay littoral cell (Figure 1). Given its proximity to the shoreline, the head of Monterey Submarine Canyon is effective at capturing littoral sediments from the north and south that are diverted offshore by the Moss Landing harbor jetties. Best estimates are that the Canyon captures about 300,000 yd3 of sand per year moving southward, and approximately 55,000 yd3/year of this sand moving northward, transported alongshore from the discharge of the Salinas River.

Historic Sand Mining at Marina and Sand City

The sand of southern Monterey Bay is economically valuable owing to high quartz content, hardness, roundness, amber color and a wide range of usable sizes. It is used for a variety of purposes including filtration, sandblasting, foundry and surface finishing. As a result, Southern Monterey Bay has been the most intensively mined shoreline in the

U.S. Sand mining near the mouth of the Salinas River started in 1906, and expanded to six commercial sites; three at Marina (Figure 10) and three at Sand City (Figure 11). Five of these operations used draglines to mine coarse sand from the surf/swash zone. In the summer months, when swells transported finer particle sizes back onshore, the operations were sometimes suspended. The sixth mine is located at Marina approximately 2.3 miles south of the Salinas River mouth, where the sand is hydraulically extracted just landward of the beach berm by a dredge floating on a

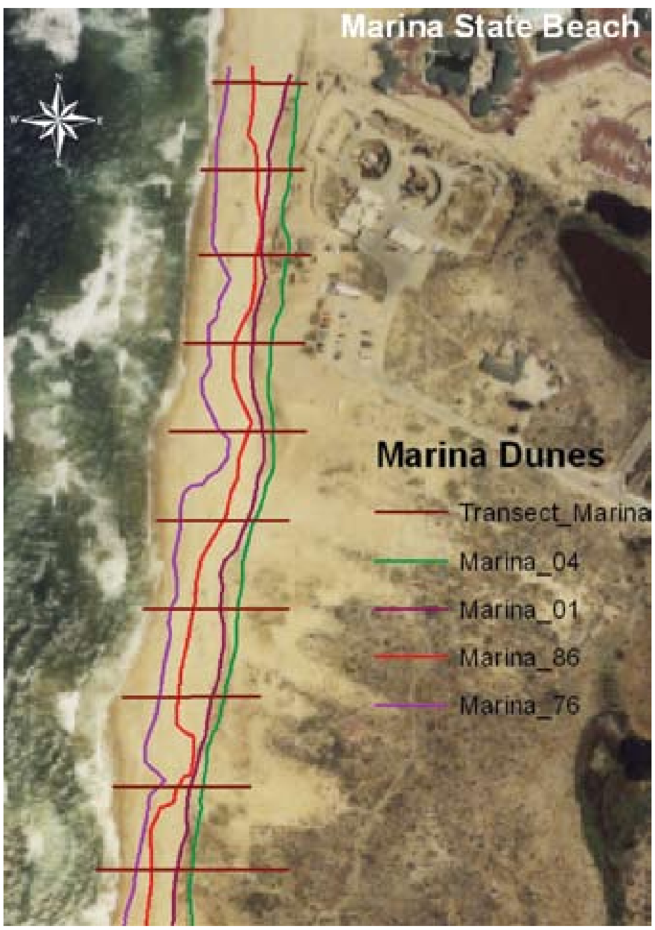


Figure 3. The changing position of the shoreline at Marina State Beach from 1976 to 2004, which has been retreating at an average rate of 5.4 ft/yr (from Gref, CSUMB).

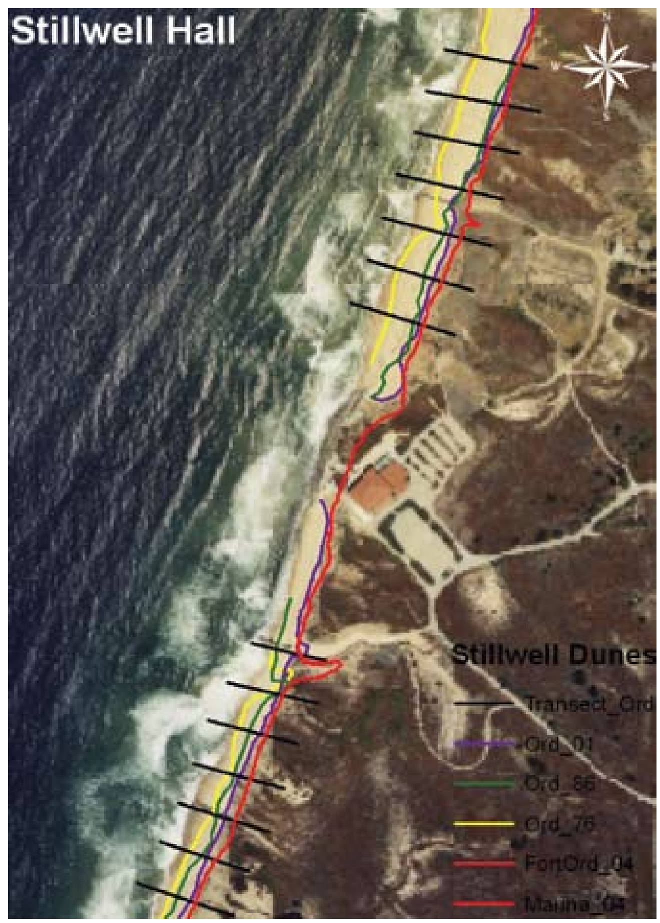


Figure 4. The changing position of the shoreline at Stillwell Hall from 1976 to 2004, which has been retreating at an average rate of 6.5 ft/yr (from Gref, CSUMB).

self-made pond (Figure 12). Although all beach dragline sand mines were closed by 1990 due to the realization that the mining was responsible for the great majority of the southern Monterey Bay shoreline erosion. The Marina operation continues to mine sand, at the rate of ~235,000 yds3/yr, with the dune shoreline of the southern bay continuing to erode.

Figure 5. The changing position of the shoreline at the Monterey Beach Hotel from 1976 to 2004, which has been retreating at an average rate of 5.1 ft/yr (from Gref, CSUMB).

Although sand mining began in southern Monterey Bay in 1906, it was not regulated until 1960, when the California State Lands Commission (CSLC) asserted jurisdiction on extractions below MHW, which by law, belongs to the State of California, and began licensing the operations through issuance of leases and charging royalties. In the 1960s, the sand mining companies obtained a court order, which made the volumes of sand mined proprietary to each other and the public, to prevent price fixing, and hence, the amount of sand mined was unknown. In the mid-1980's after a connection between sand mining and shoreline erosion was recognized, all of the permits but one were terminated. Between 125,000 and 245,000 yds3/yr were removed between the 1940's and the 1980's. Over the past 2 decades only one company has been operating, dredging about 235,000 yds3/yr from a pond on the back beach, essentially the same as the total that of the individual operations were previously removing. For some reason, despite what appears to be a very clear relationship between the volume of sand removed each year and the amount of erosion of the shoreline of southern Monterey Bay, this operations seems to have fallen outside of the jurisdiction of any permitting agency and it has continued for over 20 years after all other beach sand mining was terminated because of its recognized impact on shoreline erosion.

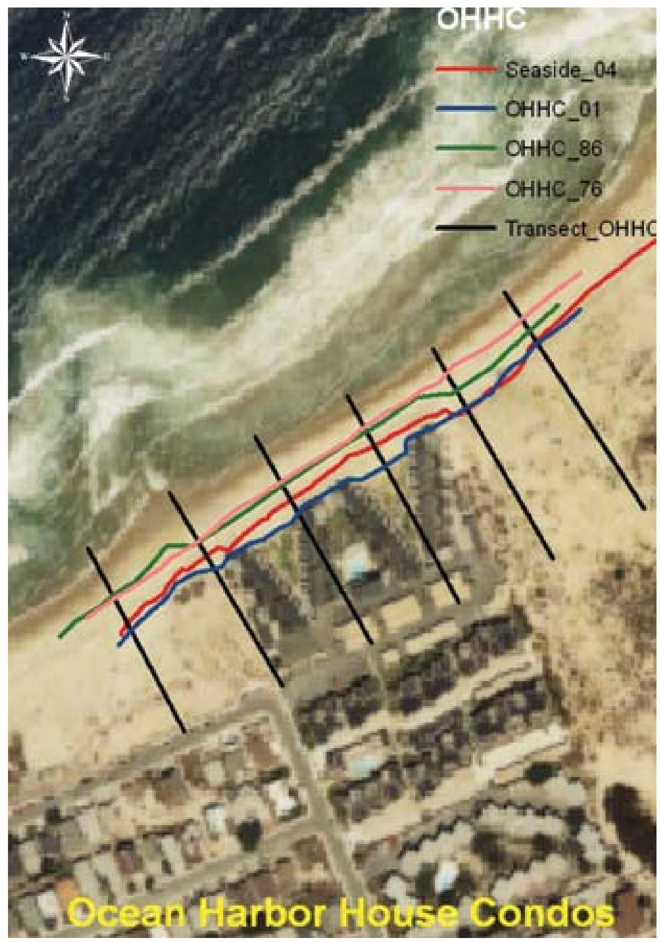


Figure 6. The changing position of the shoreline at the Ocean Harbor House Condominiums from 1976 to 2004, which has been retreating at an average rate of 2.3 ft/yr (from Gref, CSUMB).

Figure 7. Stillwell Hall, Ft. Ord (1972). Erosion rate of the sandy bluff is 6-8 ft/yr

Figure 8. Stillwell Hall, Ft. Ord (1984) with addition of more rock to the south.

At least one former sand mining operation has been redeveloped (Figure 13), in this case as a resort complex. However, the sandy bluff in front of the resort is eroding at an average rate of ~5.5 ft/year so will begin to threaten the development in the not too distant future.

Figure 9. Former site of Stillwell Hall (2005) with riprap removed and shoreline moving towards a more linear configuration.

Figure 10. Marina beach sand mining using a drag-line (1987).

Figure 11. Sand mining from the beach using a drag-line, Sand City (1972)

Figure 12. Sand mining at Marina using a floating dredge in a pond on the back beach (2005). This is the only sand mining operation currently operating in southern Monterey Bay and it removes about 235,000 yds3/yr, on average.

Figure 13. Marina Dunes Resort built on the site of one of the former Marina sand mining operations (2005).

COASTAL ARMORING AND DEVELOPMENT

Apart from short lengths of riprap and seawalls at Sand City and Monterey, the majority of the southern Monterey Bay shoreline is unarmored. Approximately 0.6 miles at the southern end of the 16-mile shoreline is currently armored (less than 4%). Shoreline armoring is focused at the privately owned oceanfront Monterey Beach Hotel and Ocean Harbor House condominiums, which between them have a history of armor placement, damage, removal and reconstruction. At these sites the shoreline is fixed, and adjacent beaches and dunes continue to erode, causing armored areas to protrude seaward into the beach run-up zones, and even the surf zone. This results in an adverse effect by blocking lateral beach access and recreation, narrowing the fronting beach, and can pose a public safety hazard. A 600-foot long concrete seawall has protected the Monterey Beach Hotel since its construction in 1968 (Figure 14). At this time, there was a sandy beach fronting the hotel. Shoreline retreat at this location, however, driven by both the loss of sand from mining and a gradually rising sea level, has been occurring at an average rate of about 5 ft/yr. During the severe El Niño storms of 1997-98 the south side of the wall was partially destroyed by large waves, requiring emergency riprap to be brought in to plug the gap in the deteriorating wall (Figure 15). Plans have been advanced to replace this old seawall. With the shoreline fixed in front of the hotel, however, continuing bluff erosion on either side of the hotel will lead to loss of beach and lateral access in front of the wall more frequently and for longer periods of time. Thus public beach is gradually being lost to protect a hotel.

Figure 14. Monterey Beach Hotel with seawall (1979).

Figure 15. Monterey Beach Hotel showing emergency riprap protecting the south side where the nearly 40-year old seawall has failed (2006). Erosion rate of dunes ~5.1 ft/yr.

Beginning in 1968 the first eight buildings (Ocean House) of an apartment complex were constructed on the dunes above Del Monte Beach in Monterey. At the time of construction, the City of Monterey allowed the front buildings to overhang the utility easement running parallel to the bay in return for all land seaward of the easement, which means the City owns all land up to the edge of the front buildings. An additional six buildings (Harbor House) were constructed further landward in 1974. Collectively, the 172 units, now converted to condominiums, are called Ocean Harbor House (Figure 16).

Figure 16. The original Ocean House Apartments above Del Monte Beach in 1972

Since its construction, Ocean Harbor House has had a history of erosion problems. Following the 1982-83 El Niño, erosion of the dunes had approached to within 14 feet of the shallow pilings supporting the complex (the bases of the pilings were at an elevation ten feet above MLLW). Emergency riprap (600 feet of rock over 20 feet high) was placed on Del Monte Beach to provide protection to the buildings but subsequently had to be removed following completion of an EIR in 1984 because of City of Monterey regulations regarding placement of materials on a public

Figure 17. Ocean Harbor House 1984 protected with riprap after 1983 El Niño erosion.

beach (Figure 17). The front regulations regarding placement of materials on a public beach (Figure 17). The front pilings were subsequently replaced with 50 -55 foot deep concrete caissons, which were poured along with grade beams to support the front row of condominiums.

Coastal erosion has continued at an average annual rate of ~1.7 ft and, despite the deep caissons and grade beams, erosion during the 1997-98 El Nino and subsequent winters, waves continued to erode the dune face back beyond the 2 rows of caissons Additional emergency riprap was required to protect the condominium units in 2002 and another EIR was completed to assess a number of longer-term alternatives to the riprap (Figure 18). While the preferred alternative was to remove the frontal units, the owners of the condominiums preferred to build a seawall to protect their property. The application was approved by the Monterey City Planning Commission, the Monterey City Council, and the California Coastal Commission, with substantial mitigation fees involving nourishing the beach in front of the seawall. As of April 25, 2008, removal of the existing riprap and construction of the 435-feet reinforced concrete seawall with engineered wave returns had not begun. The seawall will be within the footprint of the existing building foundations, and will not encroach onto the City of Monterey (Del Monte Beach) property.

Figure 18. Ocean Harbor House Condominiums (2006) showing concrete caissons and grade beams and emergency riprap. Erosion has continued at 1.5 to 2.0 ft/yr.

The proposed concrete seawall will improve protection for the condominiums but will negatively impact the public beach, including loss of horizontal access, visual impacts, reduction of sand supplied by the formerly eroding bluffs, and passive erosion, or the gradual inundation of the beach as sea level continues to rise against the fixed seawall.

Shoreline armoring in the form of concrete and other debris is also present fronting one of the former sand mining complex at Sand City. Here, remnants of a cement mixing facility are located immediately north of Tioga Avenue. The facility is now used for temporary storage of construction equipment. Until at least 1990, extra concrete slurry was dumped parallel to the shore to form an 800 feet-long concrete ridge that effectively acts as an unpermitted seawall. In addition, at the seaward end of Tioga Avenue there is a 750 foot-long collection of debris and riprap, composed predominantly of un-engineered concrete blocks, and the remains of a former road (Vista del Mar Street) where much of the asphalt has fallen over the cliff.

Figure 19. Tioga Avenue concrete and debris dumping 2005. Erosion rate ~3.5 ft/yr

CONCLUSIONS

Each of these armoring projects or efforts constitute short-term attempts to halt coastal bluff erosion and are driven by a combination of the sand deficit from the ongoing sand mining, as well as gradual sea level rise, which will likely increase in the decades ahead. We need to plan think beyond the short-term, expensive and often government subsidized or funded approaches of seawalls, riprap and beach nourishment that have guided us for so long, and develop a longer-term strategy in California, and around the retreating shoreline of the entire United States, to deal with the inevitable sea level rise of the future.

ROV Mid-water Experiments: *MBNMS R/V Fulmar*

RV FULMAR (NOAA's National Marine Sanctuary Program)

Monterey Bay Aquarium Research Institute

Ocean Science Summit

May 29, 2008

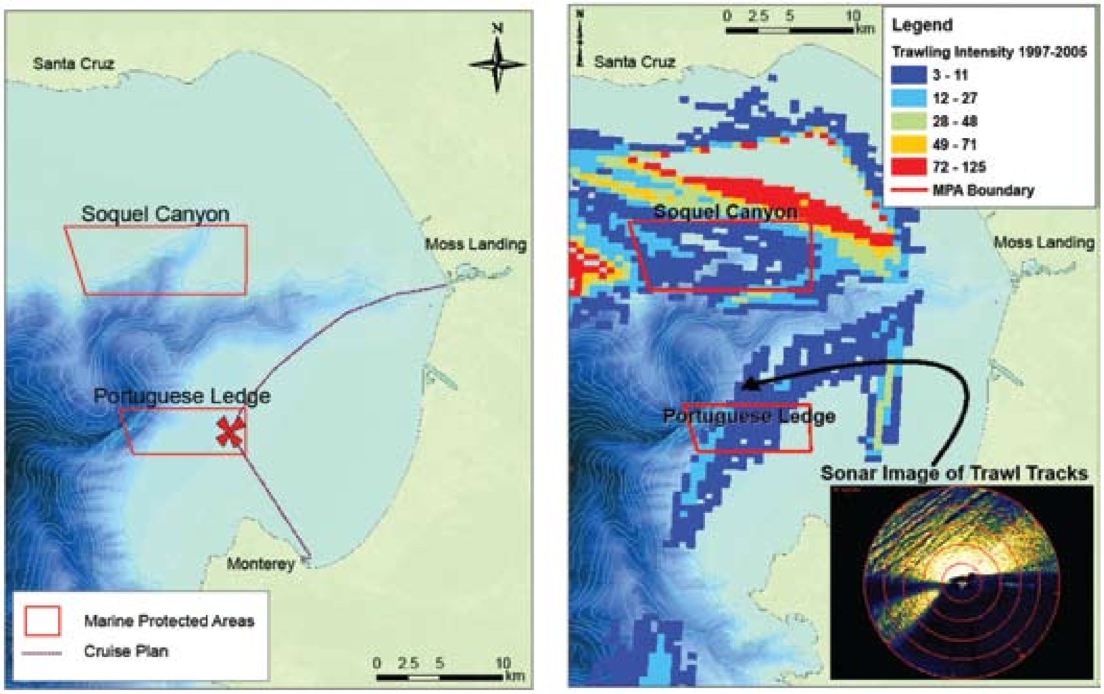
Background

NOAA's National Marine Sanctuary Program has recently added a new ship to its fleet, the 67-foot *R/V Fulmar*, which expands and enhances research, education and emergency response programs for the west coast region. The home port for the vessel is Monterey Harbor in the Monterey Bay National Marine Sanctuary, but she also serves the Gulf of the Farallones and Cordell Bank national marine sanctuaries. The vessel has a capacity of 28 scientists (day trips) and a cruising speed of 22 kts.

The primary function of the *R/V Fulmar* is research and monitoring. She is expected to be used for up to 180 key missions per year, including benthic monitoring along the remote Big Sur coastline, marine mammal and sea bird observations, tagging organisms, oceanographic monitoring, archeological/cultural research (primarily shipwrecks) and collecting baseline data for emerging management issues such as invasive species and marine reserves. Data collected during these cruises will help inform management decisions at all three sites and with state and federal partners. The *R/V Fulmar* will also serve as a platform for teacher workshops and other education and outreach initiatives.

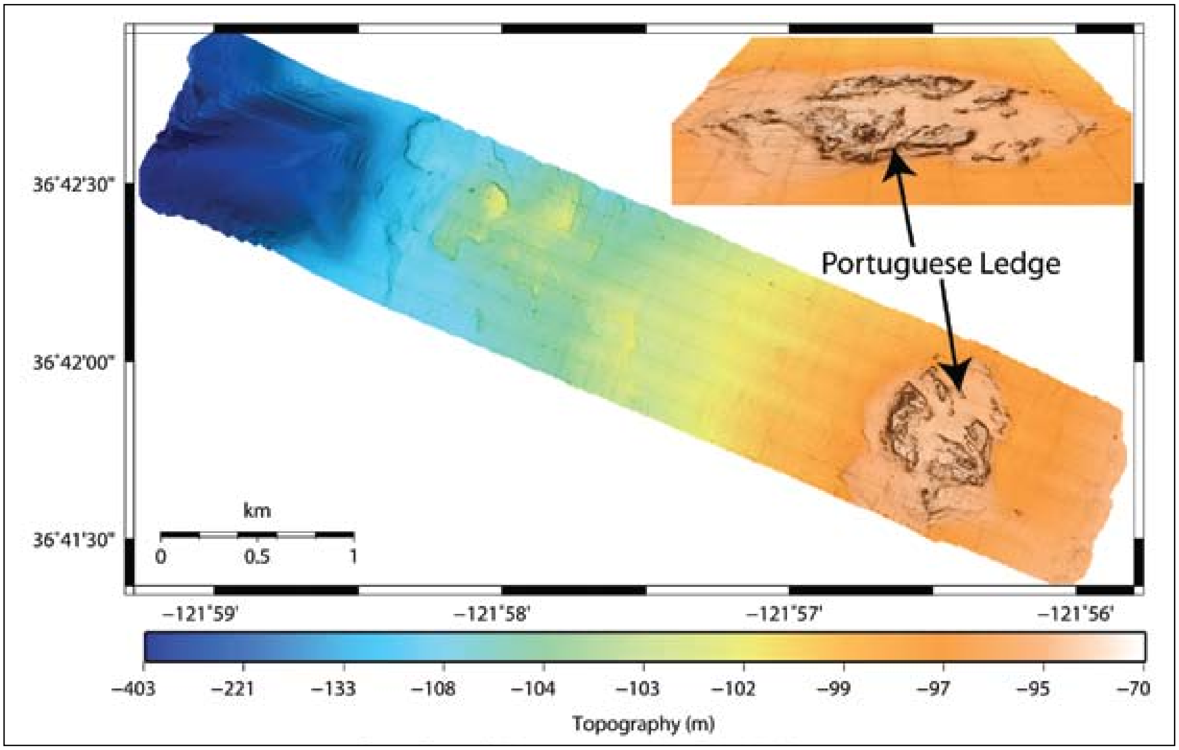
Our short cruise aboard this new vessel will provide a glimpse of the scientific support capabilities for our National Marine Sanctuaries. We will depart from Monterey for a ~30 minute steam to a small rocky reef called Portuguese Ledge at ~85 m depth on the continental shelf. This site is included in a the new Portuguese Ledge Marine Conservation Area established by the State of California to protect important fish habitat and fish populations and is part of a network to benefit the broader marine ecosystem. We will have a demonstration dive using a small remotely operated vehicle (ROV) operated by the central California National Marine Sanctuaries. During the dive we will have the opportunity to observe the rocky reef habitat of Portuguese Ledge. Depending on the time available, we may also dive in a comparable site outside the Marine Protected Area (MPA).

R/V Fulmar



Marine Protected Areas in Monterey Bay *Left: Soquel Canyon and Portuguese Ledge MPAs outlined in red. Planned cruise track shown in purple. Dive location indicated with X. Right. Recent trawling history in Monterey Bay shown with few (blue) to many (red) trawls per year. Lower Right. Sonar image collected by the ROV Ventana showing lineations produced by bottom trawlers.*

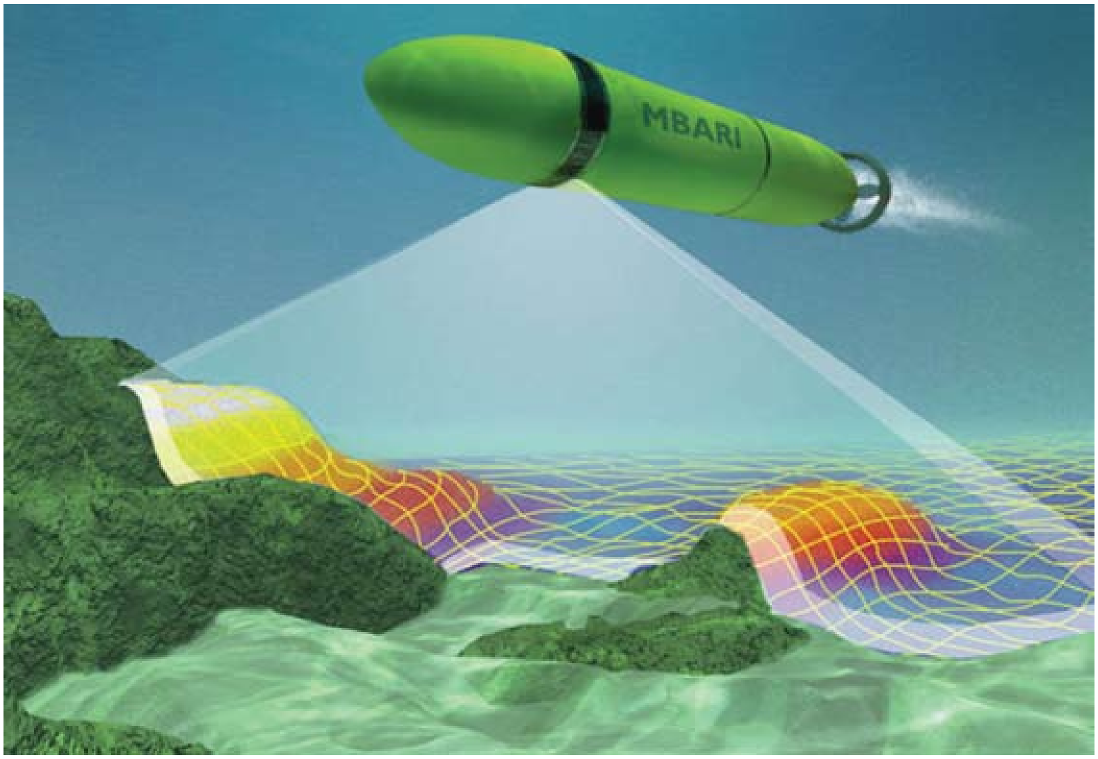
Several dozen MPAs have been created designated in California waters to protect habitat and spawning populations of fishes threatened by overharvesting. In addition to protecting fish populations, habitat protection includes reduced impacts from trawling and other fishing activities on biological communities of invertebrates that live on the seabed and create habitat structure for other animals. These include sea pens, corals, sea fans, anemones and others. Recent studies of MPAs show that these sites provide benefit for local and distant populations due to the increased survival to large size and greater reproductive output of large fishes inside MPAs, which is often exported to nearby locations. Scientists from several agencies are involved in studies of MPAs, including NOAA (National Marine Fisheries Service, National Marine Sanctuaries), the Ocean Protection Council, California Fish & Game, and Monterey Bay Aquarium Research Institute (MBARI), are using many new technologies for assessing habitat, changes in ocean conditions, and the response of biological communities to the create of these refuges from human impacts. Surveys of the Portuguese Ledge MPA are underway by NOAA to document the current status of biological communities in the MPA, using ROVs, manned submersibles, and other remote sampling techniques.



Section of Portuguese Ledge MPA

This is a high resolution map of part of the MPA created using MBARI's AUV mapping system. Depths are color-coded, and Portuguese Ledge is visible at the lower right. A perspective view of the reef is shown in the inset at the upper right.

One technology that facilitates studies of the seabed throughout the ocean as well as in MPAs is a mapping system that generates high resolution maps used to define seabed features and habitat qualities. MBARI's new mapping Autonomous Underwater Vehicle (AUV), shown below, uses a combination of an multi-beam acoustic mapping system, side-scan sonar, and sub-bottom profiling to characterize the depth, topography, and bottom type of targeted sites in very high resolution. Rather than the ~2-4 meter resolution in depth for typical nautical charts, this mapping system creates maps with 10 to 100 times the resolution, allow scientists and resource manages a much more detailed view of the seabed, thereby enabling more informed choices and decisions for resource use.



Schematic drawing of MBARI's Mapping AUV

This AUV is capable of creating high resolution maps of the sea floor using a multibeam mapping system, side-scan sonar, and sub-bottom profiling technologies. Rather than the typical bathymetric charts with a resolution of ~10 feet in depth, the new mapping system will create maps with 10 to 100 times the resolution.

Dive Plan

Once we arrive at the Portuguese Ledge dive site, we will deploy the ROV over the side of the ship, dive it to the bottom, and observe the seafloor as the Fulmar drifts slowly over the bottom. We hope to observe regions of the rocky reef with well developed biological communities, as well as others impacted by trawling activities. Total dive duration will be approximately 1-2 hours.

CRUISE PROSPECTUS
RV POINT LOBOS & ROV VENTANA

Monterey Bay Aquarium Research Institute
Ocean Science Summit
May 29, 2008

Background

The RV *Point Lobos* and the Remotely Operated Vehicle (ROV) *Ventana* are MBARI's original ship and vehicle, although both have been very significantly upgraded since their introduction into MBARI in 1987. When you embark for our brief cruise you will step aboard what is probably the most capable and accomplished scientific ship/ROV combination in the world. With over 3,000 scientific cruises and ROV dives this system has pioneered work in the deep-sea ranging from the discovery of new species to the accomplishment of advanced chemical spectroscopy at ocean depths. With this system scientists have made the transition from observing and collecting specimens to executing true advanced and sophisticated experiments at depth, requiring complex manipulations, and full networked instrumentation capabilities for real-time control.

RV Point Lobos

ROV Ventana

Our cruises are normally staged out of Moss Landing, and last a full 10 hour day. For this adventure we will for your convenience depart from Monterey, and we have only 3 hours available. We have selected a site at about 385 m depth at the edge of the Monterey Submarine Canyon for our dive – it is accessible within our time window, and has some early significance for the Institute. Immediately after the Loma Prieta earthquake of 1989 a MBARI team began searching the sea floor for evidence of quake disruption. Since so little of the sea floor had been explored it was hard to define change, but the small escarpment we will dive on was an obvious target. There were no advanced tools to mark the site available then, so the team put down a concrete block as a practical marker.

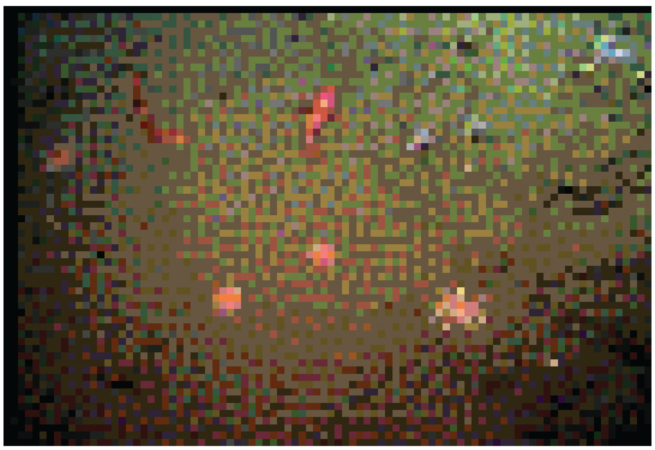
The "Concrete Block" site was visited often thereafter; it usually has an abundance of star fish and benthic animals of all kinds poised and crawling on the exposed rock walls. So there is history here, and we will have tapes of the sea floor from 20 years ago along for comparison with what we see today. From there we can quickly access deeper water, and the strange animals that live in these cold and low-oxygen/high- CO_2 waters.

Dive Plan

Our first task is to transit to the site; there will be a quick sign-in and safety briefing, and you will be oriented as to procedures and taken through the vehicle control room. With its multiple screens and control panels this can be visual overload for the untrained eye, but each screen has its purpose (or multiple uses) and all are in demand for science and safety.

RV Point Lobos Control Room

The ROV *Ventana* is an immensely capable vehicle, weighing some 7,000 lbs in air, but adjusted to be neutrally buoyant in sea water thanks to the large bright orange foam pack. After a quick pre-dive checkout (similar to an aircraft readied for takeoff) the vehicle will be lifted by crane, swung over the starboard side, placed in the water, and released. At that point the vehicle is flown by a pilot, controlling the vehicle through an armored fiber-optic cable with advanced computing and full HDTV capabilities. This leviathan can be flown with astonishing delicacy and dexterity, capturing the most delicate of sea animals in mid-water, and imaging with sub-millimeter precision the changing diameters of a cloud of bubbles rising in free ascent from the sea floor. It is a primary tool for investigating the impacts of higher ocean CO_2 levels on deep-sea animals.

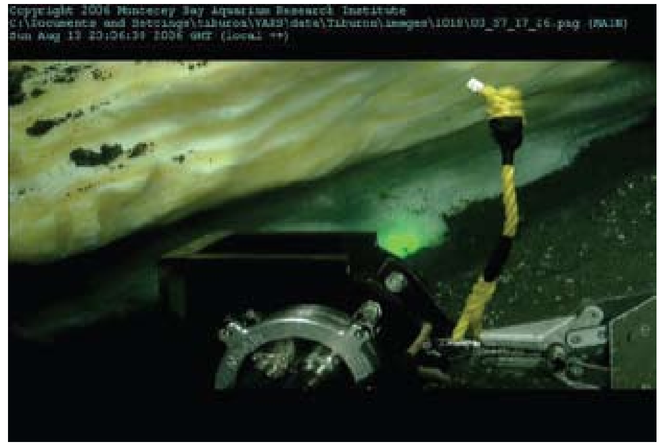


An early MBARI image of animals on the wall of the "Concrete Block" site

It will take about 15-20 minutes to dive down to our site, through a cloud of organisms of all kinds. We will locate the canyon wall, and fly along it for comparison with data from 20 years ago, recording the benthos and searching for the marked site. We may deploy some bait to show how very quickly deep-sea animals can detect the odor trail emitted, and how scavengers appear from nowhere to investigate the rare availability of food. The opportunistic ability of deep-sea creature to respond to a food fall is astonishing, and for very large targets such as whale falls truly unique and long-lived species settle as larval forms and live for years by drilling into the bones.

MBARI's mission, given in our organic document by David Packard, is to create advanced instruments and methods for deep-sea science through the combined efforts of scientists and engineers as co-equal partners. We will take along a specific example of this, and use it to demonstrate science in service to society.

One unusual example of ocean science of interest to the nation is the existence of massive quantities of methane hydrates, a form of a frozen gas-water solid that exist in sea floor sediments in vast quantities but are unstable at room temperature and pressure.



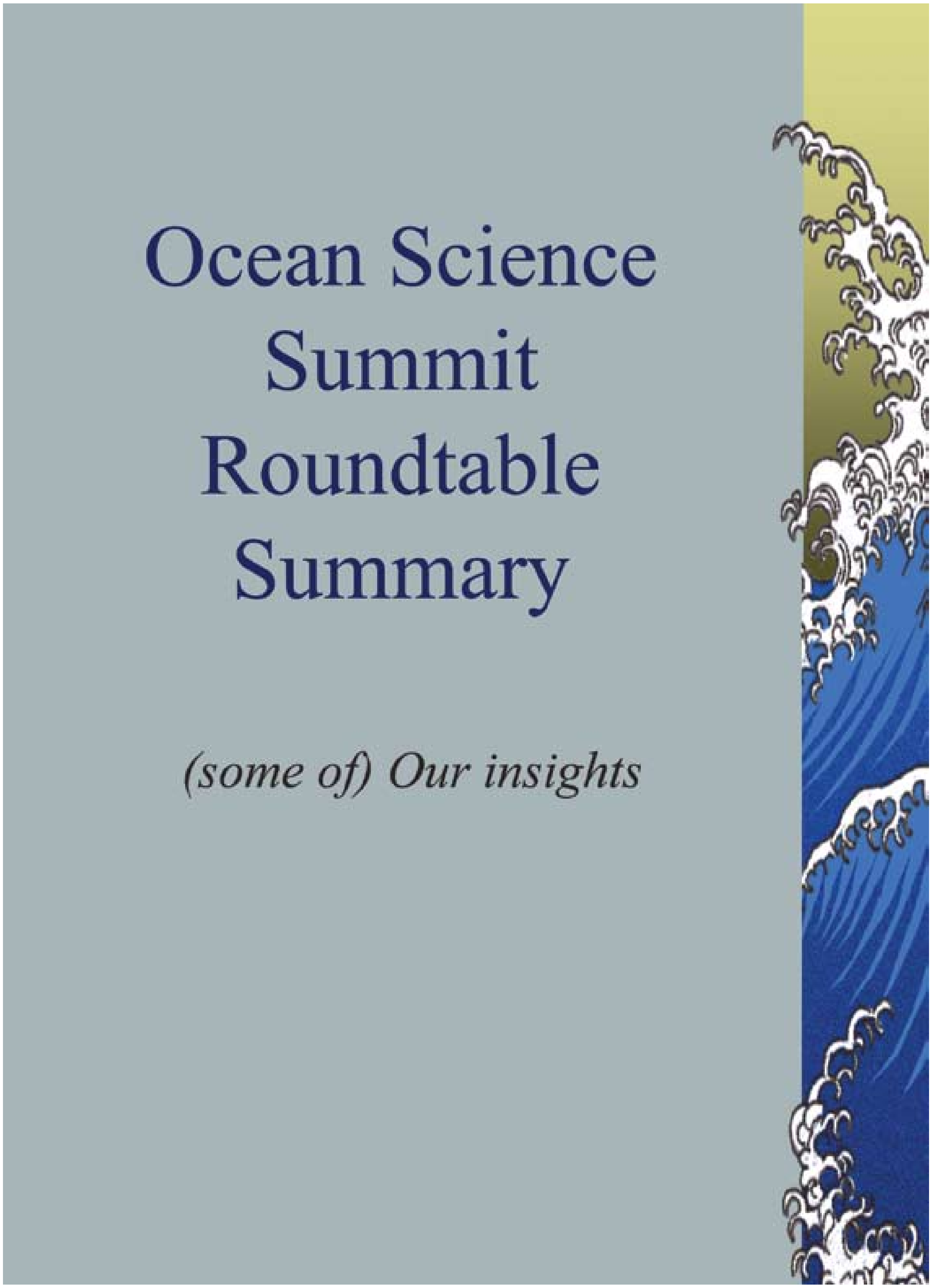
A sea floor mass of exposed methane hydrate being examined by laser spectroscopy

These are a possible future fuel source, and possible geo-hazard. No natural hydrates occur in Monterey Bay, but it is possible to create them, and we routinely do so in the deep-sea for experimental purposes. We will show the magic of transforming water and gas into a white solid using simple injection techniques developed at the Institute.

The chemical composition of hydrates is critical knowledge; basically they are formed as water cages containing a gas molecule that flutters inside the soccer-ball shaped ice lattice. We can "see" this structure simply by pointing a laser and recording the changes in the light that is scattered back from the target. MBARI has developed the unique instrumentation for this, and we will both see gas and water transform in real time, and probe the chemical structures formed. These non-invasive techniques are powerful and can be used for a very large set of deep-sea studies.

This will take the time available to us, and we will then have reached "Pull Time" and will fly the vehicle back to the surface for safe recovery and an easy ride back to the pier. There will be plenty of time for questions, and it should be fun.

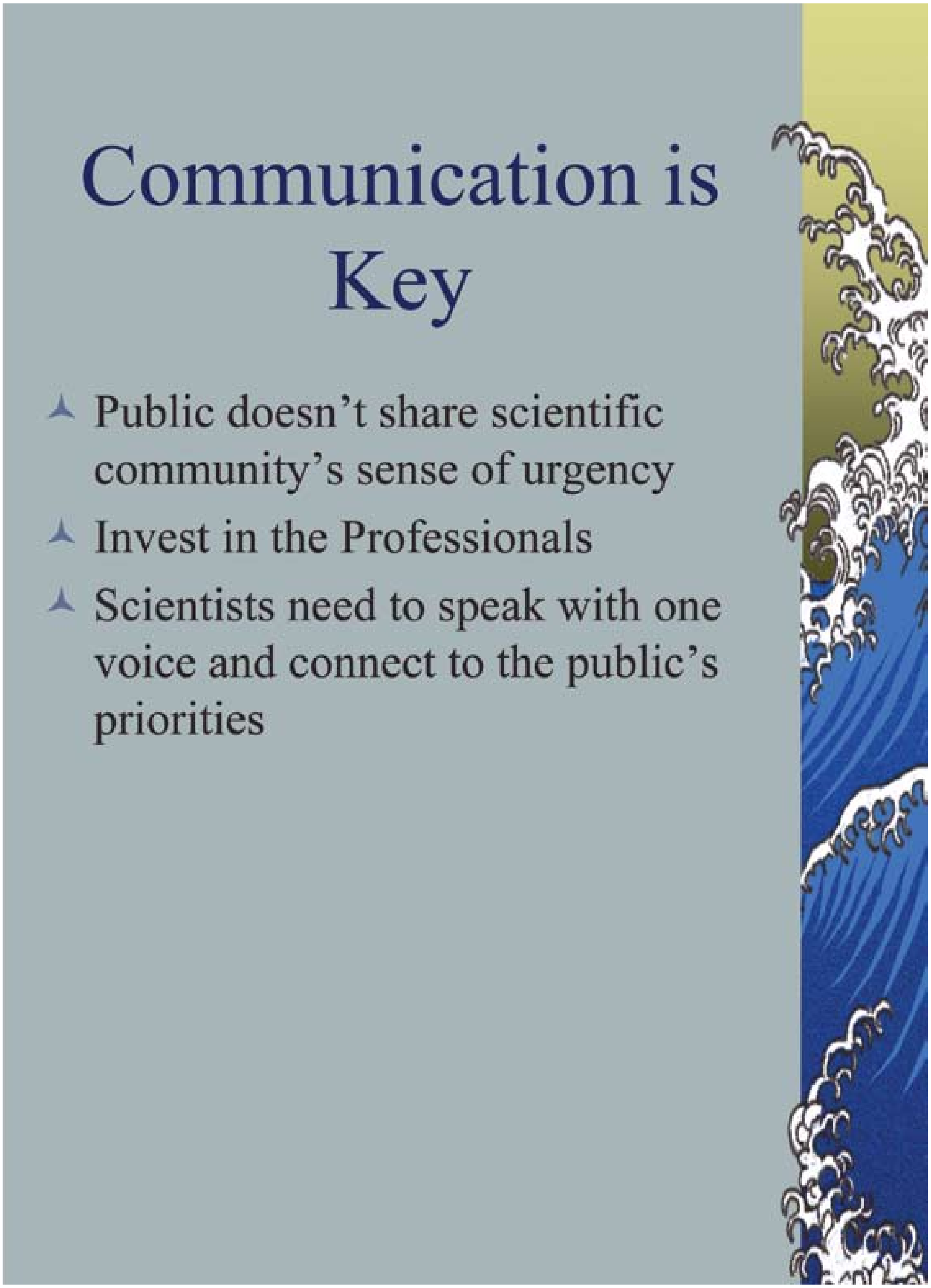
Appendix H: Round Table Discussion Summary Slides




Epiphanies
We know enough to take action now – synthesize existing data & inform policy options (this takes resources)
Continue research to ID linkages to things people care about
Communication is key –invest in the pros
Impacts are happening now – connect impacts to climate change/land-sea
Motivate action by reaching the public's hearts, guts, and wallets
We govern by crisis; public sees no crisis

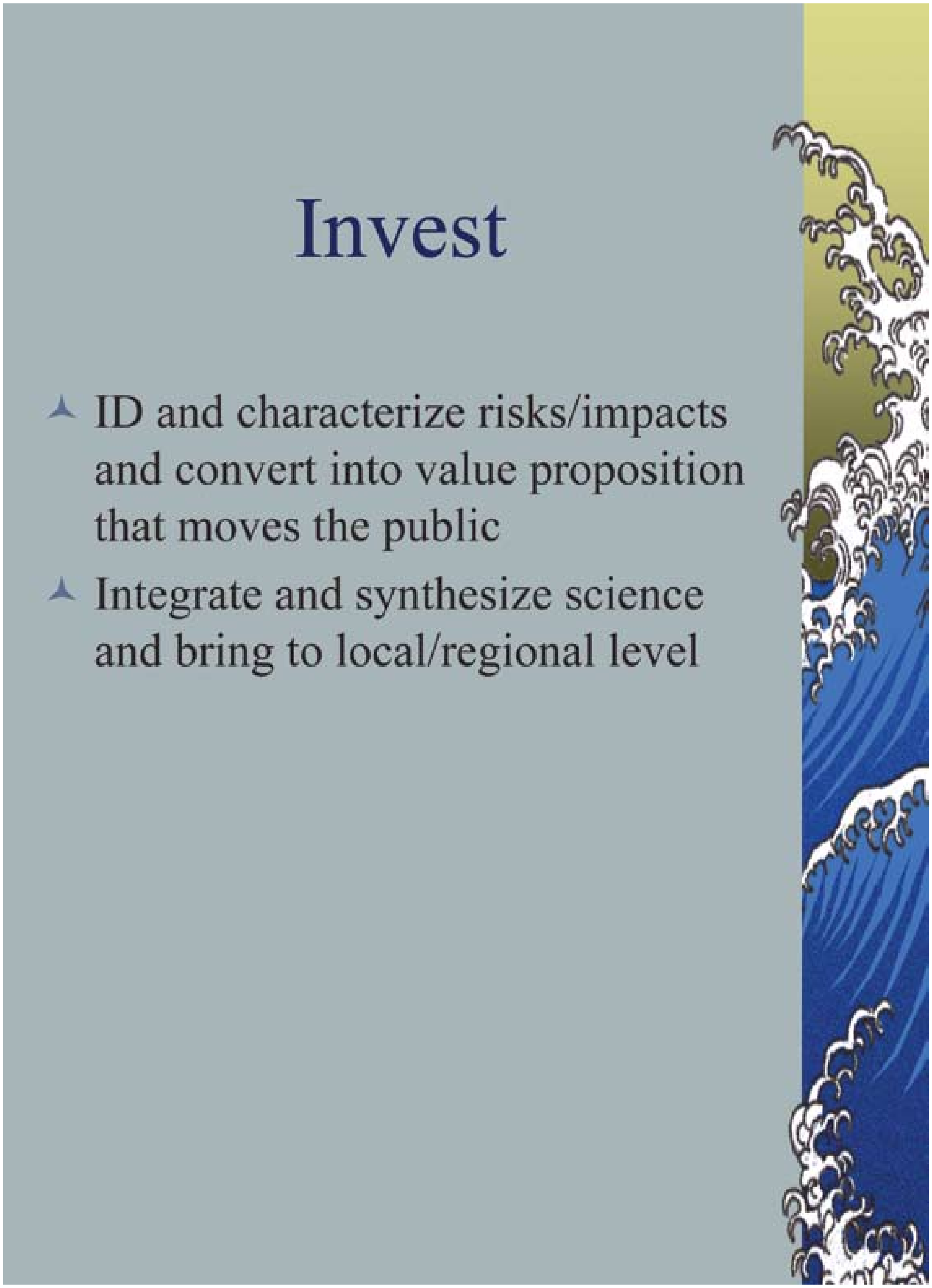
Urgent Situation

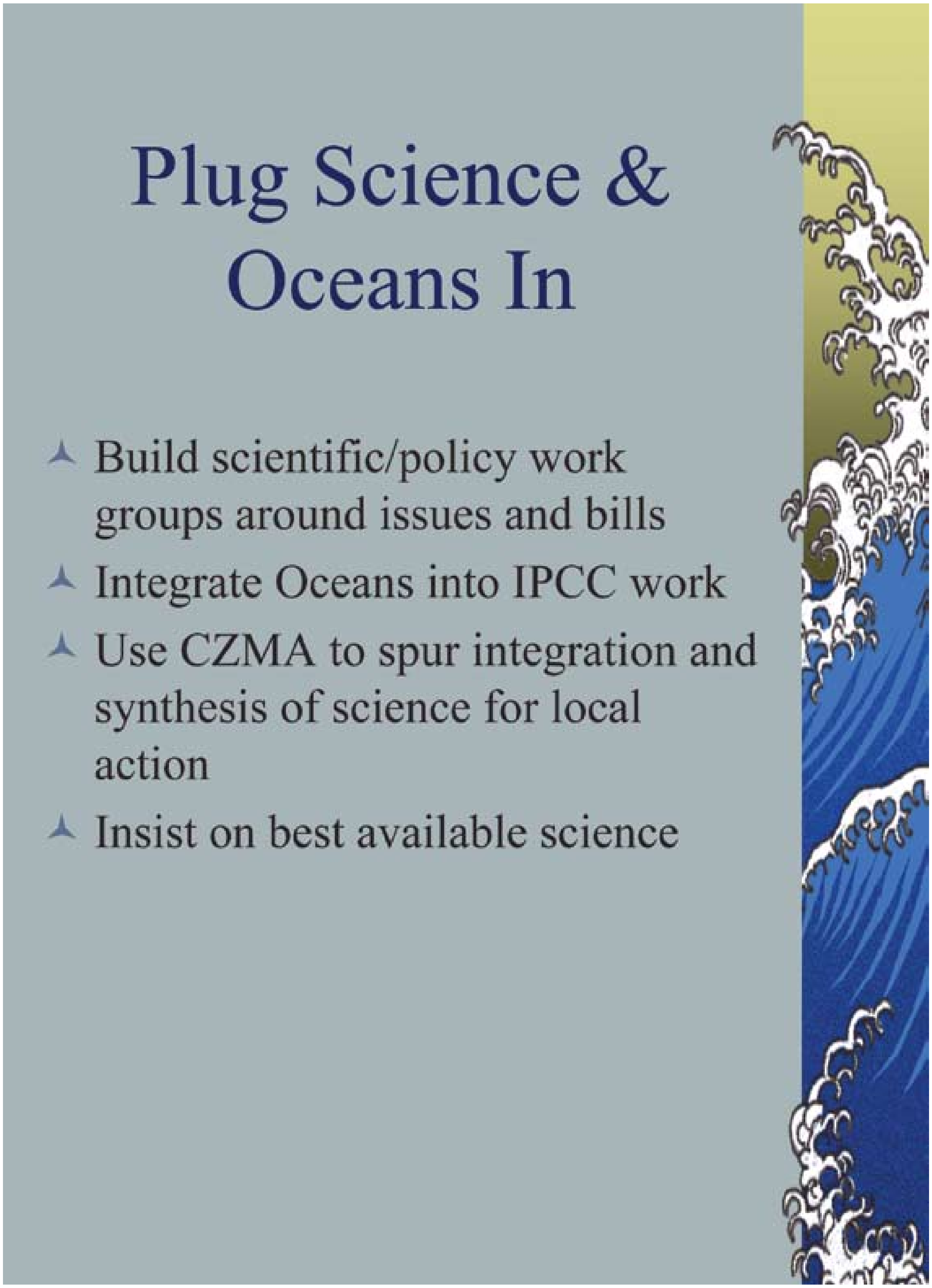
- Rate, magnitude, scale of change and impacts
- We know enough to want immediate action but need to know more about how to mitigate and adapt and what our systems will be like in 50-100 years


Communication is Key
Public doesn’t share scientific community’s sense of urgency
Invest in the Professionals
Scientists need to speak with one voice and connect to the public’s priorities

We Need Unified Policy Direction and Leadership

- Manhattan / Apollo Project scale approach: sciences, technology, policy
- Insert Oceans in every climate change effort and relate to local decision-makers
- Need high visibility champions in all levels of government, esp Executive and legislative branches


Invest
ID and characterize risks/impacts and convert into value proposition that moves the public
Integrate and synthesize science and bring to local/regional level


Plug Science & Oceans In
Build scientific/policy work groups around issues and bills
Integrate Oceans into IPCC work
Use CZMA to spur integration and synthesis of science for local action
Insist on best available science

Credits

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